PARK SCIENCE

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INTEGRATING RESEARCH AND RESOURCE MANAGEMENT

U.S. Department of the Interior • National Park Service

The application of a solar "Hot Box" to pasteurize toilet compost in Yosemite National Park

BY PAUL R. LACHAPELLE AND JOHN C. CLARK

Land managers today are continually searching for methods that promote sound and sustainable backcountry management techniques while decreasing costs and use of human resources. The public is also increasingly concerned over great expenditure for backcountry infrastructure projects including the construction of innovative toilet facilities (Voorhees and Woodford 1998). Past research has documented composting toilet technologies as a low-cost, efficient, and sustainable method of backcountry human waste treatment (Davis and Neubauer 1995; Land 1995a, 1995b; Yosemite NP 1994; Mount Rainier NP 1993; Weisberg 1988; McDonald et al. 1987; Jensen 1985; Cook 1981; Leonard et al. 1981). While considerable research has demonstrated the operation and maintenance of composting toilets in the backcountry (fig. 1), few studies have explored proper methods and disposal of composting toilet end-product.

In 1996, the USDA Forest Service, San Dimas Technology and Development Center and the USDI National Park Service, Yosemite National Park, conducted a cooperative study in the development and operation of a passive solar insulated box (termed the "Hot Box") to treat the end-product from composting toilets used by hikers in the backcountry (fig 2, this page, and fig. 3, page 20). The study demonstrated that the Hot Box could consistently meet U.S. Environmental Protection Agency heat treatment requirements and produce a class-A sludge that could be surface-applied as outlined in 40 *Code of Federal Regulations* (CFR) Part 503 (Lachapelle et al. 1997). According to the regulation, this heat treatment is a function of time and temperature (fig. 4, page 21). The study demonstrated that the time-temperature requirement could consistently be met in Yosemite, an area that proved ideal because of high ambient air temperatures and consistent sunlight throughout much of the summer.

Field staff at the park tested the application of the Hot Box to pasteurize large quantities of end-product during the summers of 1997 and 1998. Field staff report that the Hot Box operated well and required minimal labor under optimal conditions. Previously, all of the end-product removed from backcountry toilets in Yosemite was sealed in plastic bags, deposited into designated dumpsters and then thrown away in a local landfill.

PHOTOGRAPHS BY PAUL LACHAPELLE

Fig. 1 (above). A convenience to backpackers, the composting toilet represents a problem for resource managers: How to safely dispose of the human waste? The authors offer a solution based on their research of the box-type solar cooker (fig. 2, right), which they tested to pasteurize the end-product from public composting toilets used by hikers in the backcountry.

See "Hot Box" on page 20

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The editor encourages submissions from all readers and would especially like to invite contributions for the Highlights column. Please refer to the guidelines in 16(3):5-6 and on-line, or contact the editor:

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IN THE NEXT ISSUE...

Park Science will host a guest editor next time with an issue primarily devoted to the social sciences. Among the anticipated articles is one originally planned for this issue that explores the carrying capacity issue on the carriage roads of Acadia National Park (Maine). Also look for reports on a study of visitor satisfaction with transportation at Denali National Park (Alaska), a managers perspective on the Fee Demonstration Program, and politics and parks.

Size and Scope

This issue is our longest since 1986. At 40 pages, it clearly demonstrates the awesome scope and complexity of preserving natural resources in the parks. Several articles describe resource disturbances: gizzard shad at Chickasaw NRA exhibit malignant tumors, and the cause remains a mystery; hiking within a popular river canyon at Zion alters the habitat of aquatic organisms; and biodiversity associated with eastern hemlock stands in two mid-Atlantic parks could be at risk if an exotic insect infestation continues to take its toll on the forest. Conversely, at Point Reyes the elephant seal is making a comeback, albeit with such fervor that several new management issues have arisen. The stories also remind us that ingenuity, determination, and teamwork aid success. This is evident in reports on the ambitious watershed restoration activities at Whiskeytown, the desert tortoise population studies in the Mojave Desert, and the development of plant propagation programs in several parks. Our cover story goes to the heart of a nearly universal management issue: what to do with composted human waste from backcountry toilets, and the authors offer a relatively simple treatment option that is sensible, sustainable, and has broad applicability. Finally, Superintendent Karen Wade shares a personal account of the value of science in making management decisions. Her uplifting comments speak of hope and the need to keep the momentum going toward the preservation of park natural resources. This issue contributes in that vein.

Jeff

Letters from the past year

Snowmobiles

I write in response to the article "Exposure of snowmobile riders to carbon monoxide" [17(1):1, 8-10]. As a backcountry ranger and winter caretaker at Kenai Fjords National Park [Alaska], which allows snowmachine access, I feel that *Park Science* failed its readers in not taking a strong stance against snowmachine access in the national parks. If the NPS mission involves any semblance of preservation thinking, it must condemn snowmachines. Anyone who has witnessed snowmachine use in the national park system must attest to: disturbances of wildlife, noise pollution, groundwater pollution, and destruction of any aura of wilderness.

Michael O'Brien
Seward, Alaska

Science?

I received my copy of *Park Science* and the book review of *Preserving Nature [in the National Parks: A History*–17(2):1, 8]. [Since] I have not read the book, I will limit my comments to the short editorial and book review.

It is truly shameful that NPS revisionists are attempting to demonize past park managers for making parks accessible to generations of American recreationists, while promoting the new biocentric "myth" that science will lead park managers to abandon human values in favor of ecosystem preservation. In fact, to the extent that future NPS management strives to maintain or restore "pristine" wilderness ecosystems in parks, then the traditional park ideal will die, and the American people will increasingly resent the obvious damage done to their landscape experience.

Modern revisionist park managers routinely ignore science that does not meet with their preconceived notions of the world, and routinely promote new management regimes without the slightest scientific understanding of the impact on humans. The most recent examples of revisionist mythology resulted in proposals for mandatory public transportation systems and removal of the people's visitor facilities. Science is not likely to provide an enlightened future at NPS without a major injection of common sense and proper respect for history and tradition.

Kenneth A. Barrick
Assoc. Professor of Geography
University of Alaska, Fairbanks

(Editor's Note: Richard Sellars preferred not to respond to these comments.)

Preserving Nature

Having lived, worked, and suffered through the sloughs of despond that characterized the effort to create and sustain a credible NPS science program, I once more raise my grizzled head and sniff the breeze created by Dick Sellars' *Preserving Nature in the National Parks* [17(2):1, 8]. Is that real live hope I smell in the wind? Or just a wish that will expire as so many previous signs of hope have done?

The forces for status quo and inertia have carried the day so far, keeping the still magnificent park system firmly tethered to the notion that park landscapes should be moulded to human perceptions. The emulsification agent that would allow science–especially ecology–to join the traditional mix of landscape architects, foresters, and engineers has yet to be found.…

I understand that Director Stanton has undertaken once again to resuscitate our still unparalleled system and our once proud Service. If science is at last guaranteed a seat at management's head table, then perhaps the tarnished phrase "wise use" has a chance of regaining its integrity.

Thomas Hardy wrote, "If a path to the better there be, it lies in taking a full look at the worst." Science for years now has had the capability of showing us the worst and helping us avert it. So far we have elected instead to let the park system act it out. Here's one fervent Amen on behalf of the new resolve!

Jean Matthews
Former editor of Park Science
Vancouver, Washington

CD-ROM

We received the *Park Science* CD-ROM set, compiling volumes 1-18. This is an excellent use of technology, and we appreciate your efforts to get useful information to the parks.

Todd Brindle
Amistad National Recreation Area

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Science scholarship program announced for 1999

The Canon National Parks Science Scholars Program was established in 1997 to develop the next generation of scientists working in the fields of conservation, environmental science, and park management. It is the first and only fellowship program of its kind to encourage doctoral students to conduct innovative research on scientific problems critical to the future of the national parks.

The program is underwritten by Canon U.S.A., Inc. Other collaborators include the National Park Service, the National Park Foundation (NPF), and the American Association for the Advancement of Science (AAAS). Each year, the program awards graduate student scholarships in four broad disciplines: the biological sciences, physical sciences, social sciences, and cultural sciences. The amount of each scholarship is $25,000 per year, for a maximum of three years and $75,000. The program operates as follows:

1. Students submit dissertation proposals addressing specific research questions identified each year by NPS park managers
2. The proposals are evaluated by scientific panels convened by the AAAS
3. The AAAS panels select the winning graduate students who become Canon National Parks Science Scholars
4. The NPF transfers scholarship funds to each student's university
5. The students complete their graduate research, write a dissertation, prepare a popular article on the significance of the research, and give a public lecture about their work

In 1999, the Canon National Parks Science Scholars Program will award scholarships to eight doctoral students. Four honorable mentions will also be awarded and will include a one-time grant of $2,000. The 1999 competition will focus on four specific research questions described in the 1999 announcement and application.

For a 1999 announcement & application, contact Dr. Gary Machlis, Program Coordinator, Canon National Parks Science Scholars Program, Natural Resource Stewardship and Science, National Park Service, 1849 C Street NW (3127), Washington, DC 20240 or *gmachlis @uidaho.edu.* To download an electronic copy of the 1999 announcement and application, visit the NPS Social Science Web site at *www.nps.gov/socialscience/waso/acts.htm.* Applications are due June 15, 1999.

HIGHLIGHTS

APPALACHIA

Champion trees of the Smokies

During a project to identify and map old-growth forests in Great Smoky Mountains National Park (GRSM–Tennessee and North Carolina), survey notes on big trees revealed that some compared favorably to those listed as state and national champions. Subsequent surveys located new record-setting trees for over 90% of the park's common tree species based on a 1978 list. In addition, with the use of an infrared laser rangefinder and a clinometer, accurate tree heights were collected for the first time in the Smokies; thus, nearly 100 potential national and state record trees have been located and measured so far. Maintaining and promoting the park champion tree list helps to instill a sense of appreciation for what the park preserves, as no comparable region exists anywhere in the United States, not even within the southern Appalachian bioregion.

The American Forests Organization maintains a national listing of the largest known examples of many U.S. trees in the *National Register of Big Trees*. A national champion is a specimen that has the most points for its species. The point scale is based on circumference, height, and crown spread. One point is given for every inch in circumference of the trunk at 4.5 ft (1.4 m) above average ground level, every foot in height, and one-quarter of the average crown spread in feet. A tree can be listed as a cochampion if it is within five total points of another tree of the same species.

1998 national champion trees of Great Smoky Mountains NP

* indicates cochampion

Species	Circ.	Ht.	Spread	Pts
Striped maple* '97	44"	77'	31'	129
Red maple '94	276"	141'	88'	439
Yellow buckeye '95	229"	136'	53'	378
Allegheny serviceberry '96	77"	101'	36'	188
Devils-walkingstick '96	23"	74'	16'	101
Bitternut hickory '96	153"	146'	74'	318
Red hickory '97	84"	140'	62'	240
Cinnamon clethra '95	10"	33'	12'	46
Cinnamon clethra* '97	9"	29'	10'	41
Fraser magnolia '93	113"	110'	59'	238
Fraser magnolia* '81	116"	107'	55'	237
Carolina silverbell '95	152"	103'	45'	266
Carolina silverbell* '95	151"	104'	40'	265
Carolina silverbell* '95	155"	96'	39'	261
Mountain laurel '97	48"	25'	18'	78
Sourwood '94	106"	96'	28'	209
Red spruce '86	169"	123'	39'	302
Red spruce* '97	144"	146'	34'	299
Black cherry '97	210"	134'	70'	362
Chestnut oak* '96	221"	144'	78'	384
Northern red oak '97	257"	134'	81'	411
Eastern hemlock '95	202"	165'	38'	377

In the 1998 edition of the *National Register*, the park contained 22 national champion trees (five are cochampions) representing 17 species (Table). This figure is highly significant in that over 15% of our common native trees are currently the largest known of their species in the country. The potential exists to increase this figure to over 20%. While the Great Smokies recorded more national champions in 1998 than any other unit of the national park system, the park was followed closely by Big Bend National Park (Texas) with 11 champs of 10 species, and Olympic National Park (Washington) with 10 champs of six species.

In spite of its relatively small size, but with nearly ideal growing conditions, high tree diversity, and protected ancient forests, the park likely has the highest concentration of record trees anywhere in the continental United States. The champion trees of the Smokies provide the best living approximation of the quality and size of trees that once existed in presettlement southern Appalachian landscapes. Several trees recently located now represent the maximum dimensions *ever recorded* for their species. It is extremely important to realize the value of forests that in 1999 still set new standards and shatter historical records.

NATIONAL CAPITAL

Hummingbirds succumb to vegetative "Velcro®"

Last September, birders at Rock Creek Park (Washington, D.C.) discovered four ruby-throated hummingbirds ensnared in the Velcro®-like seed heads (photo) of common burdock *(Arctium minus)*, a nonnative weed that had invaded a natural area near the park maintenance yard. Three of the hummingbirds were dead, but the group was able to free one that was still alive. Resource managers removed the 50-60 burdock plants, which can grow over 6 feet in height, and plan to control the species in the future.

The occurrence came as a surprise to park staff and even an expert on burdock, leading to an investigation into the nature of the phenomenon. Could a loggerhead shrike have been the cause? Although the shrike is well known for impaling its prey on sharp objects such as thorns, the hummingbirds were not impaled; the recurved barbs of the seed head would have made this impossible. More importantly, the shrike is rare in this part of the country and at this time of year. A more likely scenario is that the tiny birds had been feeding at a nearby sunflower, lit on the burdock for a rest, and got entangled, sealing their fate.

An electronic note posted on the NPS Natural Resource Bulletin Board and a scientific literature search generated some answers. Other accounts of wildlife being caught and killed in burdock in North America are on record. According to Martin McNicholl, an ornithologist in British Columbia, this plant species has been reported to occasionally kill small birds and brown bats (*Science News* 154(16):244); indeed, a resource manager at Wind Cave National Park (South Dakota) reported the death of a little brown bat in burdock at the park more than 10 years ago. And the problem also occurs in Eurasia, the native home of burdock. Most of the information, however, is anecdotal; a cursory literature search turned up very little scientific work that quantifies the impact of noxious weeds on birds and other wildlife.

Common burdock was first documented in this country in a flora published in 1672 and is now widespread in the United States and parts of Canada. Commonly used as a medicinal herb, the plant is also well-known to farmers and ranchers who consider it a serious agricultural weed. Burs can lodge in the skin, eyes, ears, mouth, throat, or stomachs of grazing animals, causing irritation and pain. In wild mammals such as coyotes or foxes, the burs can lodge in the fur, causing it to become matted and irritated.


NPS PHOTO BY ROSA M. WILSON

One of four ruby-throated hummingbirds stuck to the Velcro®-like seed heads of

The hummingbird-burdock incident at Rock Creek Park is a poignant example of yet another way exotic plant species imperil the health of natural ecosystems. This point was amplified at a September conference on exotic plants held at the Patuxent National Wildlife Visitor Center in Maryland. Hosted by the National Park Service, the conference focused on the management of exotic plants in general. A mount of one of the hummingbirds trapped in the seed head was displayed, however, and served as a graphic reminder of the importance of preserving native vegetation habitat for wildlife.

Unfortunately, burdock is not the only nonnative plant species that has invaded Rock Creek Park. Exotic vines such as porcelain berry, Asian bittersweet, and Japanese honeysuckle are choking out native vegetation and literally dragging native trees down to the ground, destroying the upper canopy where warblers and other birds nest and thrive. Add this park's problems with exotic plant species to those of every other unit in the national park system and the scale of the problem nationwide begins to become apparent. The problem is so large that funds to combat exotics, staff positions dedicated to their control, and an organized nationwide approach for dealing with them have lagged far behind their pervasive, deleterious influence.

In early February, President Clinton signed an executive order formulating a federal strategy to deal with the problems of exotic species. The order proposes an increase of nearly $29 million for combating exotic pests and diseases and accelerating research on habitat restoration and biological integrated pest management tactics. An Invasive Species Council, chaired by Interior Secretary Babbitt, Agriculture Secretary Glickman, and Commerce Secretary Daley, will cooperate with a variety of groups to carry out the strategy.

SOUTHWEST

Interagency communications productive at Bandelier

Managing migratory wildlife where several agencies are involved is a challenge. Bandelier National Monument (New Mexico) is addressing just such a management challenge using two ongoing approaches to promote dialog between biologists and managers concerning migratory elk. The first approach is to sponsor a yearly symposium of biological research in the Jemez Mountains of northern New Mexico. The symposia have been very successful, attracting approximately 100 biologists and land managers each year. The second approach is to support and participate in the East Jemez Resource Council–an interagency group formed to promote understanding and coordination of natural and cultural resource management in the east Jemez Mountains.

In November 1998, the third symposium featured several papers on elk from both Los Alamos National Laboratory and Bandelier. Participants learned about the laboratory's elk tracking efforts that use global positioning system collars and efforts to create a predictive computer model for elk movements based on habitat, slope, aspect, and proximity to man-made structures. Presentations on simulated trampling and grazing, observations of elk behavior, and development of an elk visibility model from Bandelier's elk research program generated much interest and many questions. Also part of the symposium were papers on the 1950s rapid drought-induced ecotone shift in the ponderosa pine zone at Bandelier and a summary of vegetation recovery after the 16,500-acre "Dome" fire of 1996.

The East Jemez Resource Council was the invention of Bandelier's Chief of Resource Management Charisse Sydoriak. In 1998 the council was directed to make suggestions on elk hunting regulations to the New Mexico Department of Game and Fish. In drafting the recommendations, communications between biologists created two success stories for the park. First, a new subunit for elk hunting in areas adjacent to Bandelier will be created in the fall of 1999 to increase hunting pressure and reduce the winter elk population on the monument. Hunting in the new subunit will be limited to avoid long-period hunts that would likely drive animals onto the monument. A focus on cow-only rifle hunts will also maximize herd reduction until harvest goals are met, while maintaining quality archery bull hunts. Second, voluntary hunter check stations were cooperatively staffed by council personnel last fall to determine hunter numbers and success rate information–not otherwise available–in the planned subunit. From staffing check stations the council learned that hunter success was only 16% in the planned subunit area, approximately 50% below anticipated success. This information will be used to formulate future harvest targets in an adaptive interagency management approach aimed at accommodating both Bandelier's elk management goals and the goals of neighboring land managers.

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Cowbird impacts assessed at Carlsbad Caverns

As in many parks, parasitism of songbird nests by cowbirds is a concern at Carlsbad Caverns National Park (New Mexico). For the past three years, park biologists have been monitoring songbird nests in the Rattlesnake Springs riparian habitat to determine the extent and effects of brood parasitism by the brown-headed cowbird. They found considerably higher parasitism of the state-endangered Bell's vireo than in other songbird species. Cowbirds parasitized 13 of 15 (87%) Bell's vireo nests in 1997, causing abandonment in 6 of the completed nests. By July 1998, cowbirds had parasitized 19 of 25 (76%) Bell's vireo nests, causing abandonment in 11 nests.

Cowbird parasitism is a growing concern at Rattlesnake Springs. As of mid-July 1998, biologists had found 52 cowbird eggs in all nests, compared to 30 in 1997, and 13 in 1996. The high incidence of multiple cowbird

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Popularity of parks affects policy making

National parks are favorite destinations of national and international tourists. The steadily increasing popularity of parks reflects the rising popularity of outdoor recreation, which places substantial pressure on national parks and has important implications for the long-term preservation of park resources. If human recreation dominates the management of a park, preservation is jeopardized and the case for biocentric ecosystem management is weakened. The viability of such parklands becomes threatened. In her article "National parks and the recreation resource" (Denver University Law Review 74(3):847-58), author Jan G. Laitos examines the growth of recreation as a use of leisure time, the increased visitation of public lands (including national parks) by people who wish to enjoy the outdoors, and the subsequent shaping of fundamental management policies for national parklands.

This article is part of a special emphasis issue of the Denver University Law Review that examines numerous legal issues relevant to the management of national parks. Entitled "National Park System Symposium," the issue runs about 300 pages and includes several articles specific to natural resource management issues: "Preserving nature in the national parks: Law, policy, and science in a dynamic environment" by Robert B. Keiter; "Ecosystem management and its place in the National Park Service" by John Freemuth; "The problem of statutory detail in national park establishment legislation and its relationship to pollution control law" by Robert L. Fischman; "Repairing the waters of the national parks: Notes on a long-term strategy" by Eric T. Freyfogle; and "ANILCA: A different legal framework for managing the extraordinary national park units of the last frontier" by Deborah Williams. Details on the issue are available on the Web *(www.de.edu/law/lawreview/home.html)*.

Midsize carnivores losing ground in the West

In the West, midsize carnivores like the fisher, marten, wolverine, and lynx have become as scarce as the wild places they inhabit. These animals inhabit old-growth forests, and like wolves and grizzlies, avoid roads, clear-cuts, and people. Before the turn of the century, midsize carnivores were common throughout the Rocky Mountains and the Cascades and all but the lynx ranged south into the Coast Range and the Sierra Nevada. The increasingly sparse abundance of the animals is attributable to trapping and mostly to loss of habitat from burgeoning development and logging of old-growth forest.

Information about the abundance and distribution of these species in the West has been extremely scarce because, unlike wolves and grizzlies, the midsize carnivores have not been the focus of researchers. For years, the lack of scientific information has impeded federal listings and concomitant protection of the species by the U.S. Fish and Wildlife Service. Cutbacks or pending cutbacks of the USDA Forest Service budget have precluded comprehensive studies of midsize carnivores by that agency. Powerful profiteers and governmental agencies with missions that oppose the conservation and protection of natural resources have repeatedly thwarted attempts to curtail loss of old-growth forest by various entities. In addition to loss of habitat, the persistence of midsize carnivores is threatened by trappers in Idaho and Montana. The entire study population of a researcher in Montana was caught and killed by trappers in the early 1990s. Logging roads throughout western forests not only fragment the habitat of midsize carnivores but also permit disturbances of sensitive habitats by four-wheelers and snowmobilers and access of remote areas by poachers. "Midsize carnivores" in the West desperately need assistance with their fight for survival, but instead "are losing ground" (Joel Bourne. Defenders 72(3):14-21).

Exotic species: a costly burden

"The war against [exotic plants] takes doggedness and a long-term perspective. . . . If we want our natural areas to have the species diversity and scenic beauty they deserve, we must give nature a hand" (Tenenbaum, D. 1996. Weeds from hell. Technology Review 99(6): 32-40). Highly aggressive, persistent, and noxious exotic plants are the primary threat to many natural and restored native ecological communities. The survival of millions of acres of such communities depends on the removal of the exotics. More than 4,000 floral and faunal exotic species are able to survive without human help in the United States. Of these, 79 species cost the nation an estimated $97 billion dollars between 1906 and 1991 in damage to agriculture, industry, and health. The damage from exotics to biological diversity has not been expressed in terms of dollars; however, according to E. O. Wilson, Harvard University biologist and authority on preserving biological diversity, invasion by exotics has probably been the largest cause of extinction through most of human history. Many, if not most, biologists are convinced that a reduction in diversity robs natural communities of resilience to recover from natural disasters such as fire or storms. A reduction in diversity also constitutes an elimination of genes and substances that benefit medicine, industry, and agriculture.

The takeover by exotic species is hardly natural. In the absence of their natural predators and competitors, they can rapidly outcompete native species. The author provides examples, a few of which are given here.

The Australian tree melaleuca displaces all native vegetation in wet and dry areas. In Florida, it dominates 500,000 acres and colonizes 50 acres per day. Hydrilla, a water weed, chokes 75,000 acres of rivers in Florida. Like many aquatic weeds, hydrilla jumps from one lake to another on boats and boat trailers. Kudzu, the vine that ate the South, can grow as many as 50 feet per year and smothers everything in its path, including buildings, trees, and utility poles. In the Northeast and Midwest, Eurasian water milfoil, a submerged plant, and purple loosestrife, a showy wetland flower, aggressively and comprehensively replace native wetland vegetation. The stench from decomposing purple loosestrife is oppressive. Cheatgrass in the West carpets 100 million acres. It is highly combustible and returns quickly after fires. In other words, it fuels fires and benefits from them. Salt cedar in the Southwest has taken over streams and riverbanks. Its roots draw salt from below the soil, and its salty leaves raise the soil salinity and thereby retard the growth of native trees.

Sadly, many exotic species were purposely brought to the United States. Some plants were sold by nurseries and continue to be offered in spite of their known harm to native species. For example, 80% of Florida's exotic pest plants were sold by nurseries.

Getting rid of exotics defies simple solutions. Prohibiting the sale of foreign species would conflict with significant industrial interests in horticulture and agriculture. Banning them under the Federal Noxious Weed Act has as yet been underused. Early eradication may be best but first requires intensive public education followed by intensive public support. Another option is creating favorable conditions for native species. For example, in Everglades National Park (Florida), park staff stripped 8 inches of soil from the surface of 60 acres. In the remaining damper, lower soil, wetland species returned but not the exotic pesky Brazilian pepper tree. Biocontrol with introduced predators of exotics is controversial because of the risk that the introduced predator, also an exotic, may become a pest.

A leading role in biological controls by the federal government seems desirable, but money is in short supply. "When resources are allocated, exotics are a quiet issue and usually left to the end, even though it's in our mandate to preserve and protect natural areas," according to Carol DiSalvo, an entomologist with the NPS Environmental Quality Division who contributed to the article. Federal laws seem inadequate and not sufficiently enforced. Needed is public pressure.

El Malpais publishes natural history work

El Malpais National Monument announced in February 1998 the availability of a major new publication entitled "Natural History of El Malpais National Monument." Published by the New Mexico Bureau of Mines (Bulletin 156, 1997), the bulletin presents a comprehensive interpretation of the park's volcanic landforms and their associated biological components. Compiled by El Malpais Chief Ranger Ken Mabery, it devotes extensive coverage to lava tube caves, including their formation, mineralogy, cave ice, and fauna. Other features include a comparative analysis of seven basalt-dating techniques as applied to flows ranging from 725,000 to 3,000 years ago. The flora and fauna and the fire ecology and succession on lava flows is also cataloged. Maps, historic photos, species lists, charts, and a color photo atlas of the park's volcanic landforms are included in the 185-page volume. The bulletin is available from the publications room of the New Mexico Bureau of Mines and Mineral Resources, 505-835-5410, for $24.50.

Channel Islands I&M reports available

In the 1980s, Channel Islands National Park (California) developed a program to inventory and monitor natural resources (see Ecological Monitoring in Channel Islands National Park at *www.nature.nps.gov/im/chis/content.htm*). This program was designed to be long term and ecosystem-based. Additionally, the program was intended to provide park managers with regular assessments of ecosystem health by determining limits of natural variation, diagnosing abnormal conditions, identifying potential agents of abnormal change, and prescribing remedial treatments.

The biologists responsible for monitoring at the park produce an annual report for each program component. These reports are a description of the monitoring activities and conditions for a given year and a summary of that year's data. Abstracts of these reports are available for review at the NPS I&M Web site *www.nature.nps.gov/im/chis/abslist.htm*. The following annual report abstracts on monitoring are available: 1982-96 kelp forest, 1982-87 tidepool, 1990-92 seabirds, 1989-93 marine debris, 1994-95 beach lagoon, 1993-95 terrestrial vertebrates, 1993-94 land bird monitoring, Santa Rosa Island water quality inventory (1995), and Status and Trend of Island Fox on San Miguel Island (1998).

Additionally, the Kelp Forest Monitoring Design Review (1996) abstract is accessible on the Web site. Monitoring design review is a formal process of evaluation by managers and scientific peers of the results of a monitoring program after several years of data collection. This review process, essentially a course correction, is critical to ensure that monitoring is providing the information and statistical power that is needed by park management. The park intends to conduct such a review for all of its monitoring protocols. To date, only the Kelp Forest Monitoring Program has undergone this review.

Photocopies of the reports and program protocols may be obtained for a fee from the NPS Denver Service Center, Technical Information Center; P.O. Box 25287; Denver, CO 80225-0287; 303-969-2130; e-mail: *tic-_work_orders/requests@nps.gov*.

Trail trampling and deterioration studied

A research biologist with the Aldo Leopold Wilderness Research Institute in Missoula, Montana, conducted experiments to evaluate the effectiveness of two recommended Leave-No-Trace practices–removing boots and using a geotextile groundcloth known as scrim (Cole, D. N. 1997. Intermountain Research Station. Research Paper INT-RP-497). In four different vegetation types, 6% more vegetation cover was lost when hikers wore lug-soled boots than when they wore lightweight running shoes. One year after trampling, however, the magnitude of cover loss did not differ between the two treatments. The different footwear had no effect on vegetation height. In another experiment, the short-term loss of vegetation from trampling was half in two different types of vegetation that were covered with geotextile groundcloths than in uncovered vegetation. Although lightweight shoes and geotextile groundcloth did no harm and provided short-term benefits, they provided no long-term benefits or meaningful reduction of adverse effects on resources.

An unrelated study in western Montana explored the relative deterioration of trails attributable to different types of recreational use (Influence of llamas, horses,

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and hikers on soil erosion from established recreation trails in western Montana, USA. Environmental Management 22(2): 255-62). The research had the primary objective of assessing the relative effect of horses, llamas, and hikers on sediment yield after a simulated rainfall on established trails. A secondary objective was a better understanding of the mechanisms by which trail traffic increases erosion. The selected study site was a 1.0-1.5-m-wide trail section of Winkler gravely loams (soil consisting of clay, silt, and sand) with little entrenchment at an elevation of 1,250 m (4,100 ft). The habitat was Douglas fir and heath. Various trail traffic across seven plots was applied during June and July. Hikers wore non-lug-sole boots; horses were fitted with cleated shoes. Data were collected in dry conditions and after simulated rainfall. Under dry and wet conditions, more sediment for erosion was made available by horses than by llamas, hikers, or no traffic. More sediment became available for erosion from use by llamas than from no traffic, but yield of sediment for erosion did not differ between llamas and hikers. Traffic did not increase soil compaction on wet trails but decreased soil bulk density on dry trails. The decreased soil bulk density negatively correlated with increased sediment yield and seemed to increase trail roughness for horses but not for llamas or hikers. The data may assist managers with determining trail use by type of user.

Ungulate fence design improved

Members of the California Department of Fish and Game and the founding president of Desert Wildlife Unlimited are offering an improved fence design to protect water sources for native ungulates (Andrew, N. G., L. M. Lesicka, and V. C. Bleich. 1997. Wildlife Society Bulletin 25(4): 823-25). They set 1.5-m-long *t-posts* on 3-m centers and placed horizontal rails of either 25-mm steel pipe or 15-mm steel rebar at 50 and 100 cm above the ground. The rails were either welded or wired to the outside of the uprights. An additional t-post was attached to alternate uprights at a 30-degree angle on the inside of the enclosure to strengthen and stabilize the fence. The fence required about 30% less material and was less expensive than most earlier designs of such fences. The fence permits access by native ungulates but precludes access by feral equines (or livestock). The fence was placed around eight water sources in the field and was monitored 1989-95. Evidence of feral asses outside each of six exclosures was seen on all 127 inspections. Evidence of feral asses inside one enclosure was seen only once, namely when the fence had been dismantled by vandals.

Politics of wildfire analyzed

Severely dry conditions and gale-force winds promoted the spread of wildfire in the Greater Yellowstone Ecosystem in 1988. This ecosystem comprises Yellowstone and Grand Teton National Parks, seven adjacent national forests, and several other federal, state, and private lands in Idaho, Montana, and Wyoming. Approximately 995,000 acres or 45% of Yellowstone National Park burned. Another 590,000 acres in surrounding areas were affected by the fires. Ecologists and land managers largely agree that the fires were an ecologically important natural disturbance and that little could have been done to stop them. Policy makers on the other hand viewed the fires as failed policies, and many citizens lamented the destruction of the park, the loss of wildlife and beauty, and the adverse effects on the economy of surrounding communities. Many branded the federal government's fire policy a failure; however, scientific research and even casual observations revealed that wildlife in the burned areas abounds, trees are growing, and beauty prevails. The nearby communities did not suffer great economic hardships. In fact, nationwide publicity of the fires seems to have promoted the growth of tourism. The greatest damage may not have been from the fire, but from ridicule of the government by the public, abuse of public servants by members of the Congress, attacks on the integrity, intelligence, and professional abilities of civil servants and their associates by the media, and the public's loss of faith in the federal fire policy.

Pamela Lichtman (1998. The politics of wildfire: Lessons from Yellowstone. Journal of Forestry 96(5):4-9) contends that a realistic view of a fire policy must acknowledge that clear rules for every conceivable eventuality are not feasible. Before they can elicit support for natural fire and confidence in the federal fire policy, managers and ecologists must realize that the citizens' and politicians' view of wildfire as a crisis can undermine the stability of natural resource agencies. An honest appraisal of how much control humans have over wildfire must be clearly communicated to the public. The ecological objectives of a natural fire policy should be persuasively presented to resource constituencies and policy makers. Ideas and suggestions must be solicited from the public. Collective decision making cannot be ruled out. Quite importantly, people who are involved in conservation of natural resources cannot dissociate themselves from politics. They must understand how land management policies and ecosystem processes are interpreted and reinterpreted by citizens, elected leaders, and the media. Multiple realities and relative standards cannot be eradicated, and ecosystem management cannot progress until these realities become less disparate.

Fire and ecosystem management

A symposium at the 1997 annual meeting of the Ecological Society of America (Fire for restoration of communities and ecosystems. Bulletin of the Ecological Society of America 79(2): 157-60) addressed (1) fire as a necessary and viable option for ecosystem restoration by forest land managers; (2) operational use of fire in restoration in a complex and sometimes hostile sociopolitical environment; (3) definition of a natural fire regime for a particular ecosystem; and (4) duplication of natural fire regimes by management plans that include prescribed fire. The overwhelming message by speakers at the symposium was that fire must be an integral component of ecosystem management because its prevention in ecosystems where it was formerly common produced profound alterations in historic ecological conditions. The speakers reflected the 1996 policy by the Secretary of the Interior and the Secretary of Agriculture that "Wildland fire will be used to protect, maintain, and enhance resources and, as nearly as possible, be allowed to function in its natural ecological role." The symposium clearly established the need for and successful results of restoration with fire. The policy must be brought to fruition not only on federal land but in natural ecological communities in all ownership.

Ecosystem management activities in Southern Appalachians compiled

Lewis Publishers have recently released the book *Ecosystem Management for Sustainability: Principles and Practices Illustrated by a Regional Biosphere Cooperative*. This volume (ISBN 0-57444-053-5), edited by John D. Peine (Cooperative Park Studies Unit, University of Tennessee) includes a forward by Bruce Babbitt and contributions from 50 authors. Principles of ecosystem management from several sources are included in the introductory chapter. The book uses the Southern Appalachian Man and the Biosphere Program to illustrate the principles. Of the 23 chapters, 14 are dedicated to the following components of ecosystem management: resource assessments (Southern Appalachian Assessment); environmental monitoring (Great Smoky Mountains National Park, among several); management of a large carnivore (black bear); species repatriation (red wolf); management of isolated populations (brook trout); control of exotic species (European wild boar); control of pests and pathogens (dogwood anthracnose among several); air quality (Southern Appalachian Mountain Initiative); fire management, land use planning (gateway communities); managing biodiverity in historic habitats (grassy balds); and climate change, ecosystem stabilization and restoration (Clinch-Powell River Basin initiative), and managing a threatened ecosystem (high elevation spruce-fir forest). There is a chapter on the role of institutions in ecosystem management. Through the multi-authored contributions to this book, documentation of a comprehensive spectrum of ecosystem management and sustainable development is achieved.

The influence of land ethics on forest policy

Data from a nationwide survey of USDA Forest Service employees were used to compare the land ethics between foresters and other natural resource professionals and to examine the relation between one's land ethic and preferred forest policy options (Brown, G., and C. Harris. 1998. Journal of Forestry 96(1):4-12). The comparison revealed that foresters embrace a more utilitarian land ethic than biologists and other natural resource scientists in that service. Because the number of foresters, engineers, and range managers in the agency is declining while the number of natural resource scientists is growing, future management of national forests may be changing.

Needs assessed for marine waste disposal facilities

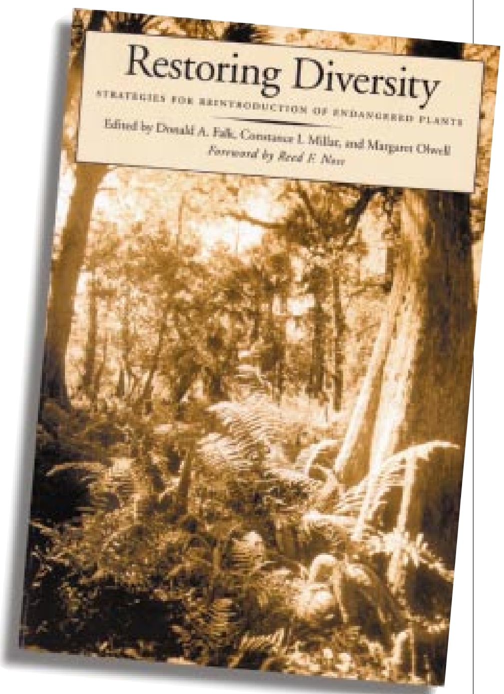
The Clean Vessel Act of 1992 (P.L. 102-587) provides for the distribution of grants to states for construction, operation, and maintenance of pump-out stations for portable toilets on boats in the United States. The article "Environmental management of human waste disposal for recreational boating activities" (Shafer, E. L., and J. Yoon. Environmental Management 22(1):99-107) is the description of a method that Pennsylvania used to estimate the number of pump-out facilities and dump stations it needed to service power boats of 16 feet in length to more than 40 feet during the May-November boating season on seven major water bodies. The estimation required the collection of information about the number and type of power boats on the water bodies; the number of boats with portable toilets or type III marine sanitation devices; the means by which boaters disposed of human waste; the number of marinas, boat docks, yacht clubs, and areas of congregation of boats in the state; the number, type, and condition of human waste pump-out facilities and dump stations; and the number of additional facilities the state needed to adequately service the current number of power boats. The information was collected by mailed questionnaires from a sample of 28% of 9,770 boaters and from 33% of all 212 marinas and boat docks in the coastal zone and inland waters of Pennsylvania. Statewide averages of the number of times a boat emptied a portable toilet or a holding tank, marina service time per sanitation device, number of hours of marina operation per weekend and weekdays, and number of weekends a marine operated during the boating season were used to estimate the required waste reception facilities for each of seven major water bodies. The study also revealed valuable information about various aspects of waste disposal. The authors discuss the limitations of the results and make suggestions for the improvement of the method.

Leopold Institute publishes research abstracts on Web

As many readers know, the Aldo Leopold Wilderness Research Institute in Missoula, Montana, is the only research group in the nation dedicated to developing and communicating the knowledge needed to improve management of wilderness and other natural areas. Founded by the USDA Forest Service in 1967, the Institute operates under an interagency agreement among four wilderness management agencies of the federal government and the USGS Biological Resources Division. Together, scientists and managers from these agencies conduct, support, and coordinate research cooperatively on the biological and social attributes and benefits of wilderness, and threats to the same attributes and benefits. Additionally, the Institute provides managers, educators, policy makers, other scientists, and the public with the results of its studies. Some 340 professional research papers, technical reports, journal articles, and books have been published since 1969 on various wilderness management issues. A comprehensive bibliography of these publications is now listed on the Institute's Web site at *www.wilderness.net/leopold;* abstracts are available for papers published after 1984. The Leopold Institute also has a new e-mail address (*leopold_institute/rmrs_missoula@fs.fed.us*) and welcomes inquiries. PS

Restoring Diversity: Strategies for Reintroduction of Endangered Plants

Edited by D. A. Falk, C. I. Millar, and M. Olwell



A BOOK REVIEW BY JOHN T. TANACREDI, PH.D.

As *Restoring Diversity: Strategies for Reintroduction of Endangered Plants* points out, restoration ecology is "mostly about restoring hope." Edited by D. A. Folk, C. I. Millar, and M. Olwell, *Restoring Diversity* can help the reader to regain the rhythm of the "environmental ministry." This book gives hope to those of us in the business of trying to reverse decades of human-induced impacts and degradation to natural systems. Though not of "biblical proportions," *Restoring Diversity* has certainly "found me." This publication should be "Gideonized" for all park managers.

Restoring Diversity is divided into five major divisions: (1) Policy for Reintroduction; (2) Biology of Rare Plant Reintroduction; (3) Reintroduction in a Mitigation Context; (4) Case Studies; and (5) Guidelines for Developing a Rare Plant Reintroduction Plan. The introduction defines the language of restoration, including such terms as "enhancement," "reclamation," "revegetation," "reintroduction." Yet despite these definitions, the authors continue to emphasize that restoration is "characterized to a marvelous degree by uncertainty, risk, and unpredictability." They do not make any apologies for what little preservation of natural systems exists today. Although heavy on "strategic" planning, the authors also provide practical applications and case studies.

Part 1: Policy for Reintroduction

The authors of *Restoring Diversity* offer no panaceas, pointing out that "in a wounded world," we have little choice but to intercede to halt or block wholesale eco-victimization. Even with the considerable number of laws passed with the intention of protecting and preserving natural areas in perpetuity, the loss of biological diversity continues in a rampant and insensible manner. To make matters more difficult, even though there is a greater awareness and appreciation for restoration and a revitalization of "managed natural areas," the "biological understanding for relocation or reintroducing species, populations, and communities is poorly developed."

Chapter 1 by Larry Morse, "Plant Rarity and Endangerment in North America," sets the tone for the remainder of the book by stating that "most reintroduction and restoration projects should be considered experimental supplements to in situ conservation." Discussion of spatial and biological scales of reintroduction assumes that the goal of rare species is to survive rather than be made common. The book thus emphasizes the difficult management task of attention to the entire landscape, including immigration-extinction, zone flow and dispersal, pathogenic impacts, habitat influences, and biogeochemistry. If at all possible our goal should be "stability" through prevention of habitat fragmentation.

Discussions of reintroduction at a regional scale and the use of the "original" site status for rare species as the reference point for reintroduction is most applicable for the National Park Service, since the authors question "how recently must we document the original presence on a site?" The authors say that many conservationists "would probably be comfortable with 10 years rather than a scale of hundreds of years unless anthropogenic pollution or causes of extirpation heavily influence species existence at a site." Those of us in federal service realize that we may never see such a progressive restoration program, because we continue to document rare plant species in a time frame of the annual base funding for such programs. We need to look more critically at the reintroduction of native species based on a documented existence in the past, and the complex causative factors that were responsible for the loss of metapopulations. The authors suggest that we should not be "overly narrow [in our] definition of the site of original occurrence." In New York City, for example, a locally rare plant *(Cyperus schweinitzii)* was found on an abandoned, concrete airfield runway that had deteriorated after 50 years of no or little use. The two small plots were isolated and fenced in. If we hadn't inventoried the site prior to our reclamation effort (spreading wood chips and letting natural revegetation occur), we would have lost this rare plant population.

Of special interest to me were the discussions on finding single populations of rare plants, which reemphasized the desperate need for unbiased monitoring to assess conservation effort success. Inventories these days are all too often conducted for environmental impact statements by "environmental consultants, contractors, or developers," who have a vested interest in keeping species numbers and diversity levels low, and who are certainly not interested in long-term preservation.

The chapter on regulatory policy by C. B. McDonald should be pulled out by land managers and kept near their telephones. This chapter emphasizes the Endangered Species Act (ESA) and was interestingly skewed in its discussion on permitting, pointing out that "no permits are required under U.S. Fish and Wildlife Service implementation of the ESA for threatened and endangered (T&E) plants!" It was good to see that the policy discussion covered the intent of the ESA to protect the "ecosystems" upon which all other species depend. The rehabilitation of impacted ecosystems is the goal, not just "save the T&E species."

The Hawaiian experience with T&E species is an eye-opener. Reading this section should rekindle, or keep lit, the fire of enthusiasm and dedication to preserve wild places before they become so degraded. One interesting note was the fact that transplantation and reforestation efforts designed to reverse the widespread impact of cattle grazing and agricultural development commenced in Hawaii in 1910 and continued through 1960; however, none of the originally transplanted native populations exist today! Today, of 103 species of native Hawaiian plants that have been transplanted into wild or semiwild areas, 35 are at risk of extinction. The discussion of "genetic pollution" or hybridization is interesting and should be the topic of a future conference proceedings.

Part 2: Biology of Rare Plant Reintroduction

Though no real "success" criteria are generic enough to be used for all rare plants and their reintroduction into natural systems, figure 6.3 covering what Bruce Povlick identified in his paper as the minimum viable population is important for land managers to review. Yet, as Povlick notes, a "minimum viable population" may be extremely difficult to maintain, especially in founding populations of rare plants. Povlick's paper presents a number of excellent case studies that set the stage for further exploration of the technical challenges of plant restoration ecology. Site introduction selection processes and population genetics with a horticultural perspective are covered by two well-referenced papers.

Richard Primacks' paper on the use of ecological knowledge to assist in reintroduction efforts emphasizes meeting all ecological requirements in order to provide a greater chance of success, measured by population dispersal beyond the reintroduction site and the "establishment of a dynamic metapopulation." Park natural resource management staff should use this paper as an introduction to the key elements that need to be identified before attempting to introduce rare plants. The intensity of such an effort will be daunting and should be acknowledged in advance by management so that appropriate resources can be made available. R. D. Sutter's paper reinforces this with his chapter on "Monitoring." He states succinctly that "if reintroduction is to be meaningful in the long term, its proponents and practitioners must acknowledge that design and planting are but the first steps in a commitment that extends for many years." Monitoring restoration and reintroduction efforts is the principle "feedback" mechanism to guide future efforts, to establish "success," and to provide input to bolster the scientific effort.

Restoring Diversity…

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Part 3: Reintroduction in a Mitigation Context

As the editors note, "the most controversial application of reintroduction and restoration" is when it is required or recommended as mitigation of some regulatory or developmental actions. I am sure all NPS superintendents have experienced a wide range of proposals purportedly being "mitigatable" through the environmental assessment and analysis process. Few of these projects are ever monitored to see if the mitigation actually worked.

Ken Berg introduces us to the definitions of mitigation and A. H. Howald reveals the complexity of actions necessary in the "California Experience," revealing pitfalls and anticipated costs and presenting site case studies. I. B. Zeller's paper on created wetlands in California is directly applicable to east coast tidal marshes, and the lessons learned from fertilization requirements, altered predator population dynamics, canopy development, and overall marsh functioning were most informative. Chapters on the "Use of Corporate Lands" in preserving plant biodiversity, and new directions for rare plant mitigation policy present several interesting approaches to protecting rare plant species. A final chapter in this section, "FOCUS: Rare Plant Mitigation In Florida," is an excellent segue into Part 4: Case Studies.

Part 4 presents a number of practical examples of rare plant reintroduction projects with their "re-introduction history." Examples of different taxa are provided. Each case includes information on threats to the population, endangerment status, site requirements, and reintroduction conditions. Even funding levels are provided to help sort out applicability to your individual needs. The book concludes with Part 5, "Guidelines for Developing a Rare Plant Reintroduction Plan," which could be used to help justify the implementation of a rare plant reintroduction program in any national park unit.

This is an excellent work that should help provide a foundation in the practice of restoration of natural systems. I recommend that all natural resources staff and superintendents in the National Park Service read it and then put into their respective libraries for future reference.

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Impacts to river biota studied in Zion Narrows

By Mikel J. Shakarjian and Jack A. Stanford

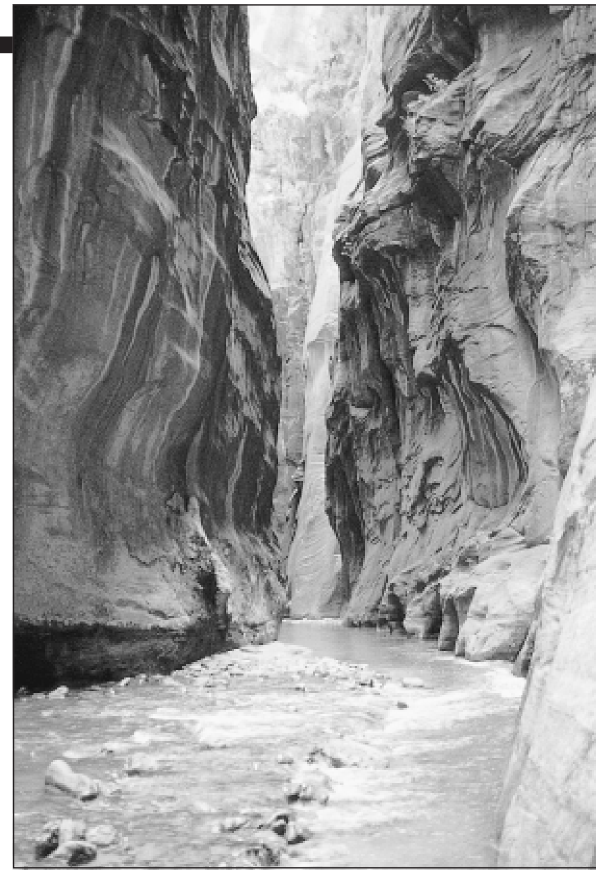
Of all the recreational opportunities provided by Zion National Park (Utah), hiking the Virgin River Narrows (fig. 1) is among the most popular activities. Annually, thousands of people wade into the waters of the North Fork Virgin River to enjoy its scenic steep-walled canyon, commonly known as The Narrows. The Narrows is not only a favored hotspot for river recreation, but also a biological oasis within the upper Colorado River system that contains critical habitat for a number of riverine species. While visitors enjoy the canyon experience, their wading activity disrupts the riverbed, altering the habitat of benthic (bottom-dwelling) organisms and potentially reducing populations.

Concern over the potential impacts of wading on river biota in the North Fork Virgin River led to a cooperative study by the National Park Service and researchers from the University of Montana, Flathead Lake Biological Station. In spring 1996, we began a study to characterize zoobenthic biomass at different locations in the river corridor. Recreational river use varied among sites and we expected to observe an impact gradient where low biomass was associated with intensive visitor use (trampling).

Visitors can enter the Narrows canyon from both an upstream and downstream location. To gain access from the upstream location, hikers are required to obtain a backcountry use permit. We relied upon the permit data to estimate hikers traveling downstream, and monitored wading activities on six separate days in August and September 1996 to estimate hikers traveling upstream from the downstream access point. Using this information, we were able to determine the average number of hikers per day passing each of our seven benthic sampling sites, providing an estimate of trampling impact at these locations. Three replicate samples were collected from each sampling site to determine zoobenthic biomass, using ash-free dry mass (g/m^2) and density (individuals/m^2).

Estimates of trampling impact within the river corridor revealed a gradient of decreasing impact upstream for all six days of the study. Trampling impact was the greatest at the most downstream site, located at the end of the Riverside Walk trail (mean =2,006), but decreased rapidly with less than 30% of the waders continuing a mile upstream to the next site at Orderville Canyon (mean = 609). Levels of trampling were very low at sites deep within the canyon. Less than 5% (mean =125) continued to the next upstream site at Big Springs and the least amount of wading activity occurred at the uppermost site (mean = 95).

With the trampling gradient established, we determined that sites with any trampling exhibited reduced benthic biomass when compared to their reference sites (no trampling), with the greatest decline occurring where trampling impact was most intense. The impact of hikers heading upstream from Riverside Walk resulted in a substantial decrease in biomass, but less than one-third of the waders actually hiked one mile upstream. Therefore, the heavy impact directly associated with the number of hikers is limited, with less than 70% of waders hiking just a short distance upstream from Riverside Walk.



Bill Hansen

Figure 1. The Zion Narrows is a spectacular river corridor that is very popular among hikers at various times of the year. The study examined the relationship between trampling of the aquatic environment and impacts to the organisms that live in the riverine habitat.

A complicating factor in this kind of analysis is the longitudinal change of the river itself. Although trampling impact was lowest at the most upstream site, the river is very narrow there (a few meters) and confined in spots by the canyon, forcing hikers to walk in the riverbed for long stretches. The size of the stream and lack of a riparian zone results in the riverbed being thoroughly disturbed by wading activity and a significant reduction in zoobenthic biomass, even though the trampling impact was quite low by comparison.

In the Virgin River Narrows, we found the level of recreational river use and site characteristics to be clearly associated with zoobenthic biomass throughout the river corridor. Our study illustrates that the trampling impact of hikers creates a serious habitat disturbance where the severity of the impact is dependent upon the level of trampling and river characteristics.

The North Fork Virgin River in Zion National Park is critical habitat for a number of desert fishes, which have experienced a steep decline in numbers throughout the Southwest and now exist only in isolated populations. Similarly, the stonefly, *Isogenoides zionensis*, is considered rare throughout its range; however, it thrives in the canyons of Zion National Park and can be found there in very high numbers. Many other important species also exist within this riverine habitat. The impact from intense recreational river use may threaten the viability of these populations due to habitat disturbance and the disruption of a healthy riverine food web based on benthic organisms. PS

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A superintendent speaks out on the value of inventory and monitoring

Remarks of Superintendent Karen Wade, Great Smoky Mountains National Park

Editor's Note: Late last summer, Great Smoky Mountains National Park (Tennessee & North Carolina) hosted the annual training session of the NPS Inventory and Monitoring Program. The weeklong event featured the following lecture by Superintendent Karen Wade. Abridged here, her remarks to the 25 course participants resulted from a conversation with Keith Langdon, the park I&M Program Manager.

I'm pleased to have an opportunity to talk about the importance of inventory and monitoring from a superintendent's perspective. Having served in both large and small areas, historic and natural, in four regions of the system, I've begun to develop some perspective on resource management that may be of value.

For the most part, parks were established for their scenic and cultural characteristics and their economic value to local or regional communities as an attraction. The National Park Service has always managed them mostly from that standpoint. Therefore, Great Smoky Mountains National Park, for example, has become known more for its huge visitation (10 million visitors a year) rather than for being a refuge for one of the richest and most diverse collections of plants and animals in the temperate world.

Like the Smokies, most of the parks in the national park system are still relatively unknown biologically. We have probably drastically underestimated the biologic value of parks, since we have only just started a servicewide approach to inventorying.

Larger parks are recognized for their natural values largely because the public hears about issues related to charismatic megafauna, catastrophic fire, and so on. But the reality is that most park units are smaller historical parks. A significant percentage of these are military sites originally selected for their importance during the Revolutionary and Civil Wars. As strategic sites, they represent regional geologic prominence or are situated at the confluence of coastal or river systems. Nonmilitary units are also often located on sites with unusual habitats. The interesting result is that these units represent both regional and national biodiversity and contain many rare species and regional endemics. Many of these units have been protected for many decades, being perhaps only lightly grazed at most, and contain natural habitats that have long-since disappeared from the surrounding landscape.

As an example, when Keith Langdon from my staff visited Shiloh National Military Battlefield in Tennessee several years ago he called attention to the fact that the park contained 150 acres of southern bottomland hardwoods that had never been cut. This is an unusually large and representative sample of that habitat. In addition, Shiloh preserves rare lichens. I really enjoyed a recent exchange with Superintendent Woody Harrell as he bragged about having more species of fish than the Smokies. I thought that was good news…a superintendent who understands that it's the diversity of the resources that matters, whether natural or cultural. I also know that Stones River National Battlefield Park in Tennessee has plants not represented elsewhere.

The superintendents of the Appalachian Cluster have begun to realize that not only have we underestimated the value of the natural resources on these sites, but that the state and federal agencies that normally use public lands for inventory work have always kept a hands-off attitude towards these federal enclaves. Even they don't have a clue what wonders exist on these lands. I wonder if the public has even the remotest idea of the wealth of resources on parklands. Interestingly, we have tended to take credit for and count the large populations of creatures in large parks, but appear to have failed to take credit for the whole range of natural communities represented on smaller properties dispersed throughout the eastern United States.

Inventories are often seen as static lists of "things." I think we don't fully appreciate that almost *any* of our parks contain surprising holdings if all species on the site were known. Inventorying becomes exciting when we think of it as the opportunity to report the treasures of regional endemics, taxa new to science, unusually vigorous populations of uncommon species critical to long-term survival, exemplary natural communities, and so on. Some large, biologically complex parks may have many more "things," but most parks, regardless of their founding legislation, contain elements that make up an exciting array representative of the diversity of our nation, region, and locality.

If inventories tell managers the full story of (1) *what* resources they have, (2) *where* these resources are, and (3) *associate* the species with other species, sites, and phenological data, then managers will have a potent tool for making intelligent decisions, taking action, and defending parks against misguided and uninformed decisions and actions from within and outside the park. This type of information allows us to be good land stewards within a regional ecosystem context.

In my view the real threat to parks is ignorance. The possession of sound scientific data is often decisive in the political arena in which superintendents, regional directors, and agency directors must operate.

Long-term ecological monitoring is the logical extension of a thorough inventory whether applied to big natural areas or small cultural areas. A monitoring program must be knit together to track key ecological processes within the larger system of which we are a part (we can't track very many individual species). The components of the system should be related to one another so that we can better understand ecosystem function. Once we have data from a site or a watershed, we have an early warning system that we can defend in a public forum or in court if we have to.

I like to use the Smokies as an example of how critical this is. Some areas here receive 300% more air pollution than others. This is significant in choosing the sites where we monitor air pollution and in choosing the watersheds we study. The associations help us understand the system and explain our case, for in the final analysis we need to score for the advantage. We can do that by understanding *all* the relationships of our resources and helping our allies understand them, too. In most places, we cannot hope to ever have the ability to monitor everything, and we have learned that

See "Wade" in third column on page 39

Figure 1. Among the many needs for native plants at Lake Mead National Recreation Area is the restoration of abandoned roads. Routine automobile traffic and camping took their toll on this desert campsite in the creosotebush plant community. Closed by the park years ago, the site has since undergone restoration.

Reflections on a desert nursery operation

Need native plants for restoration projects? Establishing a park nursery is one solution, but should be considered carefully

By Alice C. Newton; photos by the editor

Lake Mead National Recreation Area (Nevada and Arizona) encompasses 1.5 million acres of which 1.2 million are land-based. The park is managed for conservation while providing recreational and other outdoor opportunities. Spanning three of the four great American deserts–Great Basin, Mojave, and Sonoran–this national recreation area is rich in natural resources, many of which are poorly known biologically. This incredible coverage of the Southwest allows for great diversity in plant communities, such as yellow pine and pinyon-juniper woodlands, creosote-bursage scrub, Joshua tree woodland, desert riparian woodland, alkali meadows and aquatic herb, and gypsum barren scrub. Providing native plants to meet the needs of various resource management projects in these plant communities has become quite a challenge.

At Lake Mead, we use native plants for landscaping and restoration work. Our plant selection guidelines state that only native plants (with certain exceptions) will be used for landscaping and restoration in park housing, campgrounds, and other visitor areas. Concessionaires and private property owners within the park are also encouraged to use native plants obtained from the National Park Service. Restoration projects to date have involved primarily off-road vehicular damage, road and utility corridors, abandoned roads (fig. 1), and riparian areas following eradication of the nonnative tamarisk. Future restoration projects will also include vast areas of overgrazed scrub and grassland.

Opportunity

In 1991, I was hired to remove native vegetation from and later restore approximately 12 miles of Lakeshore Road that were being widened, rebuilt, and in some places, moved (fig. 2, a & b). The position was classified as "temporary, not-to-exceed four years" because this was the anticipated duration of the road project. This project, funded by the Federal Highways Administration, was a catalyst for the park to begin addressing its

Fig. 2. (a., above). Reared in the park nursery, native plants such as ash and desert willow (b., right) were used to landscape the margin of the road serving the visitor center. The nursery resulted primarily from native plant needs brought about by a major road construction project.

Figure 3. Protected from strong desert sunlight by a shade cloth laid over a steel frame, the Lake Mead nursery currently provides space for approximately 3,000 plants. The plants get their start in the greenhouse (upper middle part of photo) before being moved to watering stations (foreground) for additional growing time. Pipes made of PVC serve as slide-through pots, allowing resource managers to transplant the seedlings to various restoration sites around the park with minimal disturbance to their long and delicate roots.

long-term needs for native plant material for other projects. My function was soon viewed as serving the specific needs of the road project and the general needs of the park, and my position was converted to permanent. With additional park funding, we expanded the newly established nursery beyond what was needed for the road project and began propagating and maintaining plant material for other park purposes.

Quite frankly, building and operating a native plant propagation facility is a little tougher than it sounds. My education is in ornamental horticulture with dual emphasis on park and nursery management, and landscape design and construction. I learned greenhouse and irrigation systems engineering along with plant propagation and nursery facilities management. My practical experience included nursery operations and native desert plant propagation at a state facility, and landscape construction for private contractors. Even though I had the right education and some experience, building the nursery was an incredibly time consuming and expensive task. A productive, permanent operation requires considerable commitment not only from the nursery manager, but also from the nursery manager's supervisors and park management.

Considerations

If you are contemplating building a nursery to serve park needs, here are a few things to consider. Where will it be located, and how much land will you need? If built within a park, must land be disturbed, or can land be rented for this purpose outside the park? Do you have a reliable cost estimate for the construction of the nursery? Does the park have the expertise to build it or will you have to hire contractors? Do you have access to electricity and large amounts of water suitable for irrigation, and how reliable are these supplies? Does your location have good sun exposure for at least 8-10 hours a day, with a suitable microclimate? Can the nursery be kept secure from theft, vandalism, and herbivory? Do you know how many, what size, and what species of plants will be needed and when? How much flexibility will you have or need? Do you have, or have access to, up-to-date technical knowledge of irrigation and greenhouse management methods? Where will you get supplies? Is knowledgeable assistance available during vacations or emergency situations? How fast can someone respond to a facility maintenance emergency? Is management willing to commit long term to budgets and personnel?

These are important questions that must be answered. For example, at Lake Mead we had no suitable place to build our facility outside the park, so we built it internally. Fortunately, we were able to use the site of an old sewage lagoon, previously disturbed land, which was secure. Unfortunately, we had to run power and water to the site at a cost of approximately $15,000. We considered using treated effluent for our water source, but found it too salty for use on container plants. (We do use it for flood irrigation, however.) We spent $6,000 to surround 2 acres with chain-link fence and quarter-inch wire mesh to exclude animals and provide security, and another $6,000 on irrigation materials. Our greenhouse (only 180 sq ft–fig. 3) was built with volunteer labor and about $200 in materials, but we spent about $3,000 on the office and secure storage building. The 16 ft x 32 ft barn was built by Boy Scouts as an Eagle Scout project, but we provided the foundation at a cost of $2,500. Whenever we used a contractor, if we could get one to come out to the park, we were charged a premium for driving time.

Size

You may not think you want a nursery as large as 2 acres, but consider your plant needs over the next few years. How many 1-, 5-, or 15-gallon plants are you going to need? Are you going to need space for salvaged plants, soil, and equipment storage? What happens to the plants when the project is delayed for a year (or three)? Consider access space, too, and keep in mind that a 15-gallon plant may take two years to grow to size. Or perhaps you will just grow plants in very small containers, to save space. You will need major greenhouse space for that, at a considerable cost over outdoor space. Also, plants in a greenhouse are extremely vulnerable to environmental disturbances. In the desert, a greenhouse without power will soar to over 130°F in a few minutes in the summer, and will drop

Building a nursery to meet the native plant needs of various resource management projects at the park required careful consideration of human and fiscal resources

See "Lake Mead" on page 16

"Lake Mead" continued from page 15

to well below freezing in a few hours in the winter. Higher humidity can allow devastating fungal or insect infestations, but tiny containers and seedbeds need to stay very moist. The longer a plant is in the house, the greater the cost.

You may have the space, the water, the power, the money, the construction capability, the time, and the ambition. But so far we have only discussed the easy stuff, the onetime headaches. Doing your homework, indeed, will prevent some real migraines down the road, but you are still bound to have some problems.

Staffing

Since Lake Mead has such a wide array of plant communities, we often grow plants with variable requirements for water, sunlight, and nutrients. We have containers of different shapes and sizes, different soil mixes, nutrient mixes, and hormone concentrations. There are several stations for irrigation, capable of using one of four different watering schedules, and each using a bewildering array of parts (fig. 4). Even though our nursery is not particularly big or complex, nobody just walks in and understands exactly how we operate. An experienced nursery worker will catch on pretty fast, but everyone else will need a lot of training.

Keep in mind, too, that absences must be covered. As the nursery manager, you are responsible for the care of your plants 24 hours a day, seven days a week. I strongly urge anyone thinking about building and operating a nursery to consider splitting the responsibilities between two people. This does not necessarily mean two full-time staff, but the nursery manager should always have trained staff to fall back on during vacations, other projects, illness, and other emergencies. Someone who knows how to repair a valve or major line break, program the clock, and is familiar with the watering needs of individual plants is invaluable to any nursery. This is most easily accomplished when the backup person is a part of the daily operations and knows the routine.

Figure 4. Raised in a harsh desert environment, plants at the nursery require constant care while the bewildering array of plastic watering lines demands continual vigilance. A power outage, leak, or break in a line could spell disaster for these fragile propugules in a relatively short period of time.

Weighing alternatives

By now you may be reevaluating your notion to start a production nursery. What are the alternatives? Perhaps you could share expenses with a nursery already established in your cluster in exchange for plant material. Among the desert parks of the Pacific-Great Basin Cluster two have production nurseries, one at Lake Mead and the other at Joshua Tree National Park. The Joshua Tree operation is geared toward arid plants such as creosotebush *(Larrea tridentata)* and bursage *(Ambrosia dumosa)*, while the Lake Mead operation can accommodate several thousand riparian plants such as Goodings willow *(Salix gooddingii)* and cottonwood *(Populus fremontii)*. The remaining desert parks in this cluster may take advantage of these facilities when needed. Perhaps you have an agricultural or horticultural college, a Natural Resource Conservation Service facility, or a private production nursery within a reasonable driving distance of your park that would grow materials for you under contract. Be aware, however, that contract growing has certain disadvantages that include inflexibility and lack of knowledge of native plant propagation and maintenance. Many native plants have no established methods for reproduction in a nursery, and trial and error propagation by a contract grower may prove to be very costly. Additionally, many contract nurseries are not oriented toward genetic diversity, preferring to clone plants like factories. But if you require material for one project only, a good contract grower may be just what you need.

Eight years ago, Lake Mead National Recreation Area had no means of addressing its growing need for native plant material. In contrast, during 1999, the park will devote a full-time position to rearing almost 10,000 plants of 30 species for use in five major park projects. Additionally, we will be able to provide material for many smaller landscaping and restoration projects. What began as a way to meet the needs of a road restoration project has lead to an ongoing nursery operation to meet the needs of the park for the long-term supply of genetically diverse, native plant materials. Filling this niche for the park is personally satisfying, as is getting out in the nursery early in the morning, sharing space with birds and the occasional rattlesnake, and caring for the living beings I helped to create. The journey has been a real challenge, but over all, well worth it. PS

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Figure 1. In 1994, Mount Rainier National Park constructed a "coldframe" to serve several purposes. Its primary function is to provide growing space to "harden off" recent transplants (established in the greenhouse) before moving them outdoors to the lathe house. During winter the space is used for stratifying seeds, mixing media, and washing pots. This spring recently potted heathers (2-3 years old) will be moved here.

The propagation of three greenhouse programs in the Pacific Northwest

By Regina M. Rochefort, Matt Albright, and Pat Milliren

Restoration of human impacts has been an integral part of park management in the Pacific Northwest for over 50 years. Photographs from the archives of Mount Rainier National Park (Washington) illustrate revegetation of damaged areas in the subalpine life zone as early as 1930. In the 1970s, backcountry hiking reached record highs in Olympic and Mount Rainier National Parks, creating the need for many of our current restoration projects.

Small beginnings

In 1970, park volunteers Joe and Margaret Miller began a project in North Cascades National Park (Washington) that provided the catalyst for the complex restoration programs that now exist in North Cascades, Olympic, and Mount Rainier National Parks. The Millers showed that greenhouse propagation of high-elevation, native plants was possible and greenhouse transplants would survive in subalpine environments. In 1989, a regional revegetation committee was established. This committee provides a forum for discussion of field restoration and greenhouse methods. Although the committee meets infrequently, restoration specialists in the three parks talk frequently and try to meet at least once a year.

Currently, all three parks have restoration programs that use both greenhouse plants and on-site techniques such as seeding, layering, and transplanting. Greenhouses in each park were funded by different sources and have different staffing levels. Restoration personnel collaborate on development of greenhouse techniques, monitoring systems, and field guidelines for collection of plant materials. Each park has different specialties: North Cascades opened the door to greenhouse propagation of native species; Olympic made high-volume production of native heathers commonplace; Mount Rainier focused on plant collection guidelines and diversity in species production. Recently, we have collaborated on a Challenge Cost Share project with Dr. Yan Linart of the University of Colorado. The goal of the project is to develop plant collection guidelines that protect genetic diversity of native species. Field research was conducted on two species common to each park: *Aster alpigenus* and *Carex spectabilis.* Our intent is to develop guidelines that can be extended to other species with similar life history characteristics. Although the mainstay of each program has been high-elevation species, we are all venturing to lower-elevations species. Our reason for writing this article is to let others know the many different routes we have used to fund our programs and continue to manage them. We welcome questions, discussions, or suggestions from others contemplating or managing greenhouse programs.

Complex of North Cascades parks

In 1969, soon after the park was established, Superintendent Roger Contor recognized the problem of existing vegetation damage and the potential for increased damage at subalpine passes within the complex (North Cascades National Park and Ross Lake and Lake Chelan National Recreation Areas). Camping and climbing impacts were apparent at Cascade Pass, which was also an ancient trail used by native people traveling to the "east side" of the state. Other passes would become more vulnerable as State Route 20 was completed providing a route to the east side. In 1969, the superintendent hired Professor Dale Thornburgh, Humboldt State University, to survey bareground impacts at several passes and make restoration recommendations to the park (Thornburg 1970). Subsequently, longtime park advocates Joe and Margaret Miller volunteered to begin on-site rehabilitation experiments at Cascade Pass. After spending a couple of summers in the field, the Miller's started propagating native plants in their home greenhouse. By 1975, they convinced the park to build a small cold frame (48 sq ft).

See "Northwest" on page 18

"Northwest" continued from page 17

In 1976, Park Ranger Bill Lester, with the Miller's help and labor from the Young Adult Conservation Corps built the park's first small greenhouse (800 sq ft) in the town of Marblemount. Lester and numerous Native Plant Society and other volunteers donated many hours of greenhouse propagation time in addition to field planting time in an effort to restore the documented impacts at Cascade Pass and other backcountry sites. Around 1990, Lester was able to supplement the greenhouse budget by obtaining a contract to grow low-elevation native plants for landscaping the site of the park's new visitor center in Newhalem.

In 1990, Lester and Resource Management Specialist Jon Jarvis obtained an NRPP (Natural Resources Preservation Program) grant to build a larger, more modern greenhouse for propagation. The new greenhouse is adjacent to the ranger station/wilderness information center so that visitors seeking information and backcountry permits can see the greenhouse and learn about the restoration program. The new greenhouse was dedicated to the Millers in 1993. It encompasses 1,728 sq ft and cost $62,000 to construct; construction of outdoor beds, work areas, and shaded space was completed in 1998 with financial support from Seattle City Light mitigation funds. The funds are set aside for erosion control projects around Ross Lake NRA.

Currently, the North Cascades revegetation program is supported by a ranger (Pat Milliren) in the wilderness district. Pat's position is a nine-month subject-to-furlough position; she supervises the greenhouse/wilderness revegetation program. A 12-week Student Conservation Association (SCA) volunteer position is dedicated to the program, and critical assistance is received from Washington Native Plant Society, the Mountaineers organization, and other volunteers. Most plants are grown for impacted sites in the subalpine zone (5,000-6,500 ft elevation). Annual greenhouse production rates are currently 1,000 plants per year. Species grown include woody heather shrubs *(Phyllodoce empetriformis, P. glanduliflora, Cassiope mertensiana),* grasses, and sedges *(Carex sp., Phleum alpinum, Trisetum),* and herbs *(Antennaria sp. and Potentilla)*. While wilderness restoration focuses on subalpine sites, the greenhouse will continue to produce plants for lower elevation sites for specific projects in developed zones.

Figure 2 (above). Affording some protection from the elements, the Mount Rainier lathe house exposes seedlings to colder temperatures than they experienced in either the greenhouse or the cold frame. Plants thus accumulate carbohydrates (i.e., "harden off") and become better able to withstand adverse environmental conditions.

Figure 3 (right). A donation enabled Mount Rainier to build this 18,000 sq. ft. greenhouse in 1995. Native plants make their start in this temperature controlled facility, which also includes plumbing and benches.

Mount Rainier National Park

Mount Rainier's greenhouse program began in 1972 with the construction of a 240 sq. ft. greenhouse at park headquarters in Ashford (about 1,500 ft elevation). This greenhouse was used only sporadically until the park established a botanist position in 1984. When the first author of this article arrived at Mount Rainier, Superintendent William Briggle and Assistant Superintendent Robert Dunnagan stated that one of their goals was a park-wide restoration program that included an active greenhouse propagation program. With advice from the North Cascades staff, the greenhouse program was initiated in 1984 with production of 2,700 plants in 1985.

Over the past 12 years, greenhouse staffing, budget, and structures have slowly increased. Our first expansion was to obtain an SCA to staff the greenhouse for 12 weeks each summer. Gradually, shade houses and small coldframes were built with leftover PVC pipes, lumber, and pallets from other projects. We built lathe houses to protect and harden-off plants during the summer before they were transplanted in restoration sites. Plant production increased each year until 1988 when 10,000 plants were produced. In 1990, production increased to 16,000 plants when funding was available to support a year-round seasonal biological technician (Davis 1991; Rochefort and Gibbons 1992). In 1994, a 20 ft x 48 ft coldframe (fig. 1, page 17; cost $2,000) was constructed for propagation of heathers (*Phyllodoce glanduliflora, P. empetriformis,* and *Cassiope mertensiana*) and other shrubs that required two years in the greenhouse. The lathe house (fig. 2) was slowly expanded to cover 3,456 sq ft. In 1993, funding allowed for a permanent horticulturist position (GS-437-07) through the servicewide resource professionalism initiative. Ann Bell was the park's first horticulturist, and under her direction plant production increased from 20,000 plants in 1994 to 40,000 plants in 1996. Additionally, we received a private donation for $17,000 that the park was able to match to build an 18,000 sq. ft. greenhouse (fig. 3) in 1995 (total cost $38,000 for materials and construction including benches, electricity, and plumbing).

Currently, Mount Rainier grows about 20 species each year from a palette of about 50 plant species including shrubs such as heathers and huckleberry *(Vaccinium deliciosum),* sedges (*Carex* spp.), grasses, and flowers (e.g., *Aster* spp., *Potentilla flabellifolia, Erigeron peregrinus*). Most of our restoration sites are in subalpine areas at elevations of 5,000-7,200 ft where we use species that are easily grown from seed or soft wood cuttings. Recently, we have started growing plants for restoration projects in the low-elevation developed zone; project funding covers propagation costs of $1-$3 per plant. The annual budget for the greenhouse fluctuates with funding levels between $6,000 and $15,000 (park base) in addition to the horticulturist's salary. The greenhouse staff includes one SCA, volunteers, and often a GS-05 seasonal biological technician. Most of our seeds for greenhouse propagation are collected by volunteers from the Olympia Native Plant Society. With the construction of a new greenhouse, we have increased annual production to 70,000 plants and developed a cadre of greenhouse volunteers under the direction of Horticulturist David Palumbo.

Olympic National Park

Backcountry revegetation for the restoration of eroded and trampled sites in wilderness is not new to Olympic National Park. Through the late 1970s and early 1980s revegetation was carried out at a number of popular wilderness camping areas throughout the park. In those days we used local transplants for spot planting in impacted areas to restore local plant communities. Although current projects rely more on greenhouse plants than local transplants, revegetation with plant material collected at the site has always been an important component of Olympic's restoration program.

During 1987, the park constructed a greenhouse for the production of road-edge plants for a federal highways project along the Sol Duc road. This began a new approach in restoration at the park concurrent with greenhouse propagation programs at North Cascades and Mount Rainier National Parks. Seedlings and rooted cuttings were propagated from plant material collected from precisely defined plant communities occurring along the Sol Duc road corridor. This program enhanced existing contracts with private growers and seed programs with the former Soil Conservation Service (now the Natural Resource Conservation Service). The greenhouse is 20 ft x 40 ft and was constructed by park carpenters during the winter. Total cost for the greenhouse is estimated at $22,000-$25,000; $13,000 for materials and the remainder for labor by park carpenters. Funding was provided by park base and project funding. The success of the Sol Duc restoration program demonstrated that the park greenhouse could provide the quantity of transplants needed for large-scale revegetation projects.

In 1988, with the completion of the Sol Duc Road project, Ruth Scott, Wilderness Resource Specialist, adopted the park greenhouse facility to reestablish a wilderness restoration program in montane and subalpine areas of the park. Beginning with easy-to-propagate species such as sedges, grasses, and forbs, greenhouse manager Matt Albright then expanded the program to include the more difficult to propagate ericaceous shrubs. After initial experimentation with two subalpine heathers, Phyllodoce empetriformis and Cassiope mertensiana, production methods from cuttings and seeds were developed for a number of highcountry ericads. Since 1991, these ericad species have comprised an increasingly large proportion of greenhouse plant production.

For several years, the greenhouse staff has maintained an annual production level of 20,000-30,000 transplants of a wide range of species including ericads, subalpine shrubs, trees, forbs, grasses, and sedges. With the initiation of the Sand Point Restoration Project along the park's wilderness coast, the greenhouse has started producing low-elevation coastal species. In the fall of 1996, 14,000 starts of lowland shrubs, sedges, and grasses were planted in the Pacific maritime spruce forest. An additional 35,000 transplants were propagated for spring and fall planting in 1997. The greenhouse is maintained by one permanent, subject-to-furlough horticulturist and one half-time employee assisted by a cadre of local and seasonal volunteers. The staff follows an annual cycle of fall cutting propagation, winter seed processing and sowing, spring and summer transplanting and fall out-planting. The single most expensive and labor intensive task in the revegetation is packing thousands of potted plants and providing for their transport to backcountry destinations via helicopter. In addition to base funds, the wilderness restoration program has been supported by grant funds such as the Canon USA-National Park Foundation "Expedition into the Parks" conservation program and the Washington State Nonhighway Off-road Vehicle Access Program, and volunteers from organizations such as the local Sierra Club Service and Wilderness Volunteers.

Summary

Greenhouse propagation of native plants has been an important and integral part of restoration programs at Mount Rainier, North Cascades, and Olympic National Parks for over a decade. Due to the number and magnitude of human impacts in our wilderness and natural areas and our short growing seasons greenhouse propagation is a necessity for effective revegetation of denuded sites. Although our programs have many similarities, funding sources, staffing, and production levels vary among programs and between years. We would like to offer our assistance and experience to anyone trying to start a greenhouse propagation program.

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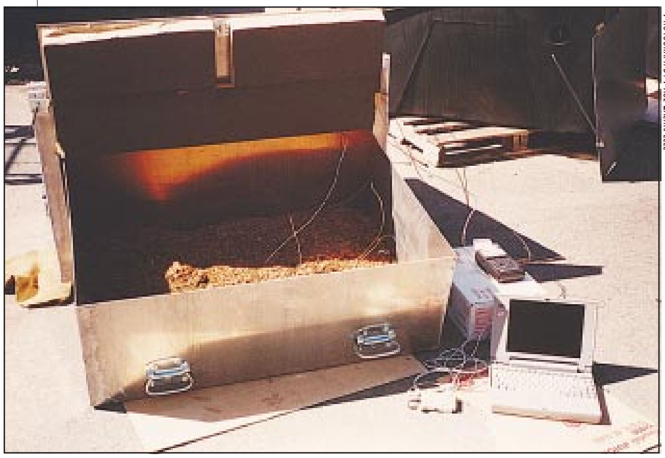
"Hot Box" continued from cover

Now the pasteurized end-product is surface-applied out of the park in local flower gardens near the park headquarters in El Portal.



Photograph by Paul Lachapelle

Figure 3. Two time-temperature data loggers were used to record and compare temperatures within the Hot Box. Temperature probes were inserted into various sections of the compost pile through a small hole in the back of the Hot Box. A laptop computer was used to download and display the data from the data loggers.

Background

The development of backcountry composting toilet methods resulted from the need to reduce impacts including surface water pollution at overnight sites. Research of backcountry composting systems began in the mid-1970s and focused on sites with up to 2,000 overnight visitors per season (Fay and Walke 1977; Ely and Spencer 1978). Composting technologies became increasingly popular as research documented the ineffective breakdown of coliform bacteria using the "cat-hole" disposal technique (Temple et al. 1982) and as certain composting toilet technologies were shown to be a low-cost and effective solution to human waste treatment and disposal (Leonard and Fay 1979; Leonard and Plumley 1979). Thermophilic composting (also termed "batch" or "bin") and mesophilic composting (also termed "moldering" or "continuous") have been used with varying degrees of success in numerous national parks (Yosemite, Mt. Rainier, Olympic, Grand Canyon) and national forests (White Mountain, Green Mountain).

The aim of any composting technology is to optimize conditions for microbial growth. Combining the proper amount of carbon (also termed "bulking agent" and usually consisting of wood chips or shavings), moisture, ambient heat, and oxygen enhances the living conditions within the compost pile for natural oxygen-using microorganisms (aerobes). These aerobes use human waste as a food source, and consequently, the waste decomposes over time into a soil-like substance. Disease causing organisms (pathogens) within the human waste are reduced or eliminated due to competition, natural antibiotics, nutrient loss, and heat. The human waste and the carbon are in most cases manually mixed in an enclosure or sealed bin. The term end-product refers to the composted wood chips and human waste. The composting process functions optimally with a carbon to nitrogen ratio of 25-35:1 and a moisture content of 60% (Davis and Neubauer 1995). The aim of thermophilic composting, which requires frequent mixing and high wood-chip input (approximately 1 kg [2.2 lb] of carbon to 1 liter [~1 qt] of human waste), is to kill pathogens quickly and with hot temperatures. These temperatures result from microbial activity and can exceed 45°C (113°F). Once a sufficient amount of human waste has been collected, a compost "run" is started and can take up to several weeks to complete. Mesophilic composting in comparison is a long-term method that can take years to effectively reduce pathogens within the waste. This method differs from thermophilic composting because the frequency of mixing and the amount of carbon added are considerably lower with temperatures within the waste pile ranging from 10°- 45°C (50°-113°F).

Complete pasteurization of composting toilet end-product by either treatment method, however, can never be guaranteed and depends on the quality of field staff maintenance and site conditions. Heat treatment, such as the Hot Box can provide, is one method to ensure pathogen reduction and meet 40 CFR Part 503. Consequently, the Hot Box can help in a number of ways. First, if land management policy dictates that the end-product can be surface-applied at the backcountry toilet site, significant savings in transportation costs could result. Additionally, the biophysical and social impacts from using either pack animals or helicopter resources could be reduced. Second, while land management policy may dictate that the end-product be transported outside of a protected area boundary, heat-treated compost is less of a health and safety issue to field staff. End-product that is heat-treated in the backcountry would be a considerably lower health hazard to field staff regarding accidental spillage during transport or disposal. Since, for example, a fundamental tenet of the Wilderness Act states that the wilderness area be "protected and managed so as to preserve its natural conditions" (Wilderness Act of 1964, Sec 2c), surface-applied compost in these areas could be problematic. Unquestionably, increased nutrient levels resulting from on-site disposal could upset natural species assemblages by shifting the competitive advantage to invasive nonnative plant species; however, in areas with less stringent land policies, surface application of treated composting toilet end-product could be appropriate. For instance, there are several national forests where both mesophilic and thermophilic composting toilet end-product has been approved for on-site disposal. Nevertheless, state laws may be more restrictive than federal policies and therefore the land manager should review all applicable regulations. Third, if the end-product cannot be surface-applied at the site and the Hot Box cannot be used in the field because of staffing or ordinance issues, landfill disposal savings could result. Lastly, the treated end-product could be reintroduced into the composting toilets as bulking agent, which would reduce the amount of additional bulking agent needed.

Hot Box description and application

The Hot Box is a nearly airtight container that allows solar shortwave radiation or light energy to pass through the glazing (see fig. 2, page 1). The contents of the Hot Box absorb the light energy and convert it to long-wave radiation or heat energy, which becomes trapped inside the box. The 1996 USFS/NPS study demonstrated that temperatures of over 100°C (212°F) can be achieved and temperatures of 88°C (190°F) can be sustained for several hours.

The outside walls, floor, and removable tray are fabricated from an approximately 0.5-cm thick (0.2 in) aluminum sheet. A single transparent Lexan® Thermoclear polycarbonate sheet is used as the solar

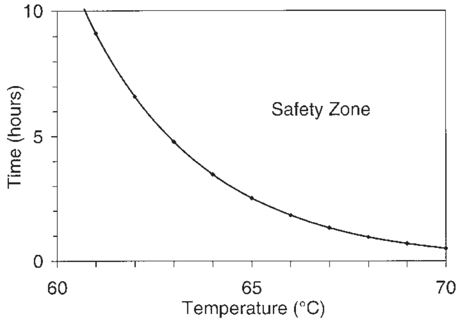


Figure 4. U.S. Environmental Protection Agency 40 Code of Federal Regulations (CFR) Part 503 time-temperature relationship for the heat-treatment of sewage sludge.

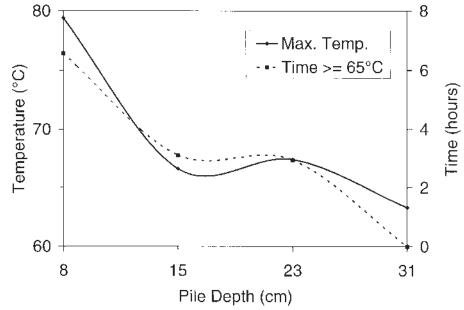


Figure 5. Comparisons are made between pile depths, the maximum temperature attained and the duration in hours at or above 65°C. Moisture content of the compost pile is equal (33.5%). Temperature readings are taken from the middle of the compost pile.

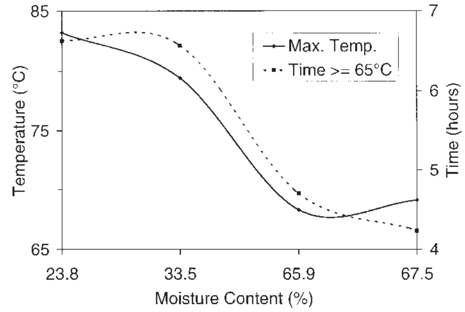


Figure 6. Comparisons are made between percentages of moisture content, the maximum temperature attained, and the duration in hours at or above 65°C. All pile depths are equal (8 cm). Temperature readings are taken from the middle of the compost pile.

glazing and is bolted at an angle specifically designed to maximize the angle of incidence during the summer solstice for the chosen latitude (at Yosemite, 38° N, a 15-degree angle was chosen). This angle could be adjusted for other locations. The inside walls and floor are insulated with 5-cm (2-in) polyisocyanurate closed-cell foam. A door is positioned at the back of the Hot Box in order to gain access to the tray. The original Hot Box measured 122 cm x 94 cm x 69 cm (48.1 in x 37 in x 27.2 in) at the highest end and 46 cm (18.1 in) at the lowest end. Four new Hot Boxes, measuring 122 cm x 122 cm x 61 cm (48.1 in x 48.1 in x 24 in) at the highest end and 20 cm (7.9 in) at the lowest end, have recently been built and appear to be more efficient because of their larger glazing and decreased internal air volumes.

Yosemite field staff operated the Hot Box during the 1997 and 1998 summer seasons at the park headquarters in El Portal, which is outside the park. Yosemite contains six backcountry composting toilets that collectively produce approximately 20 m^3 (700 ft^3) of end-product per year. Traditionally the end-product has been transported outside the park boundary.

End-product is transported in double plastic bags by pack animals to trailheads and then trucked to El Portal. Approximately 9 m^3 (300 ft^3) were pasteurized in 1998. Field staff emptied a portion of the bags into the Hot Box tray and allowed the compost to pasteurize for up to one week. One operator required one-half hour per day, two days per week, to perform this task. The 1996 USFS/NPS study concluded that pile depths of 12 cm (4.7 in) or less and two and one-half hours of direct sunlight with ambient air temperatures exceeding 28°C (83°F) were most effective at meeting the time-temperature requirement (fig. 5). Additionally, a moisture content of 60% or less allowed for maximum temperature attainment (fig. 6). Field staff would mix the end-product in the Hot Box tray several times during the heat-treatment process to ensure thorough pasteurization. After pasteurization, the finished compost was again bagged and brought to local flower gardens and spread thinly on the surface. Operators reported that the pasteurized compost resembled mulch and not human waste in both texture and odor, and was therefore more tolerable to work with.

Conclusion

The passive solar Hot Box has been used for two field seasons in Yosemite National Park, a location that is shown to be ideal to effectively pasteurize the compost from backcountry toilets. This application stems from the 1996 USFS/NPS study that demonstrated the use of the Hot Box as an effective method of pasteurizing the end-product from composting toilets. Field staff report that the developed Hot Box technology requires a minimum level of attention and maintenance by the operator and produced a compost that is dryer and appears less offensive to handle and transport.

While stringent regulations may negate the possibility that finished compost be surface-applied in wilderness and national park areas, the Hot Box holds tremendous potential to save either transportation costs and associated impacts in areas where the end-product can be surface-applied on-site, or disposal costs where the end-product must be transported and disposed off-site. This passive technology can serve as a sound and sustainable backcountry management technique, alleviating impacts, costs, and extensive use of human and animal resources, while providing an added safety margin to field personnel. PS

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See "Hot Box" in right column on page 24

PHOTO BY KATHIE MEYER

Figure 1. Desert tortoises, represented by this male photographed in Joshua Tree National Park, have the greatest latitudinal distribution of any of the four North American tortoises ranging from southwestern Utah to northern Sinaloa State in Mexico, a range of 1,100 km (683 mi). Across this vast range, the desert tortoise occupies a staggering diversity of plant communities from tropical deciduous thorn scrub in Mexico, across the Mojave and Sonoran Deserts, to the edge of the Great Basin Desert and the Colorado Plateau.

Studies of reproductive output of the desert tortoise at Joshua Tree National Park, the Mojave National Preserve, and comparative sites

BY JEFF LOVICH[1], PHIL MEDICA[2], HAL AVERY[1], KATHERIN MEYER[1], GILLIAN BOWSER[3], AND ALAN BROWN[2]

The stability of any population is a function of how many young are produced and how many survive to reproduce. Populations with low reproductive output and high mortality will decline until such time as deaths and births are at least balanced. Monitoring populations of sensitive species is particularly important to ensure that conditions do not favor decline or extinction.

Turtles, including tortoises, are characterized by life history traits that make them slow to adapt to rapid changes in mortality and habitat alteration. Long life spans (in excess of 50 years), late maturity, and widely variable nest success are traits that allowed turtles to outlive the dinosaurs, but they are poorly adapted for life in the rapidly changing modern world. Increased mortality of young and adults can seriously tip the delicate balance required for turtles to survive.

The desert tortoise

The desert tortoise (fig. 1) is a federally threatened species to the north and west of the Colorado River with full protection under the Endangered Species Act (Ernst et al. 1994). The listing of the tortoise in 1990 was based on the perception of rapid population declines due largely to human-induced changes in the Mojave Desert ecosystem (Fish and Wildlife Service 1994; Lovich and Bainbridge, in press). The Recovery Plan for the desert tortoise, prepared by the U.S. Fish and Wildlife Service, identifies research on the reproductive output of the species to be a high priority for land management agencies tasked with the responsibility of recovery, and we hope, future delisting. To that end, in 1997 we initiated research on the reproductive output of the desert tortoise at several study sites in the Mojave Desert. Research support has been generously provided by the U.S. Geological Survey, Joshua Tree National Park, the California Desert District of the Bureau of Land Management, the Palm Springs-South Coast Resource Area of the Bureau of Land Management, Banning Veterinary Hospital in Banning, California, University Orthopedics, in Las Vegas, Nevada, and J. F. Kennedy Memorial Hospital in Indio, California.

Previous research on reproductive output of desert tortoises conducted by Fred Turner, Phil Medica, and others in the early 1980s demonstrated a strong correlation between clutch frequency, or how many clutches a female produces in one reproductive season, and biomass of annual plants that tortoises utilize for food. Production of annual plant biomass is in turn related to the timing and quantity of rainfall. One of our goals is to obtain more detailed data on the relationships between rainfall, annual plant biomass, and various measures of tortoise reproductive output. The information generated will provide resource managers with models relating reproductive output of tortoises to easily measured environmental variables. Such data are especially important in areas where tortoises and livestock may compete for resources such as food plants.

Study sites

The three study sites established in the spring of 1997 included Joshua Tree National Park, the Mojave National Preserve, and another in an area administered by the Bureau of Land Management (BLM) near Palm Springs, California. Two additional sites were added in the spring of 1998: one in Piute Valley, Nevada, and one in St. George, Utah, both on lands administered by the Bureau of Land Management. Studies in Utah are being conducted in cooperation with U.S. Geological Survey Research Biologists Todd Esque and Dustin Haines. The sites in the Mojave National Preserve and near Palm Springs are located in active cattle grazing allotments.

Methods

Thirty-six female tortoises were equipped with radio transmitters in 1997 (fig. 2), located at weekly or biweekly intervals April-July, and x-rayed (fig. 3) to determine the presence of shelled eggs. The x-ray procedure exposes tortoise embryos to radiation

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PHOTO BY JEFF LOVICH.

Figure 2. Research biologists use many tools to collect data. Desert tortoises, like this female photographed in Joshua Tree National Park, are frequently equipped with radio transmitters for projects that require tracking and relocation of individual animals. Valuable data on movements, home range and other behaviors are obtained from studies using this technology.

doses much lower than internationally accepted levels established for developing human embryos (Hinton et al. 1997). Studies in the Mojave National Preserve were complemented with the use of ultrasound technology to determine the presence and size of follicles (eggs) prior to their detectability using x-radiography.

Results

At the Palm Springs site, 9 out of 10 females produced a total of 72 eggs in the 1997 reproductive season (one produced no eggs). Of these nine females, six produced second clutches and at least one produced a third clutch. Mean size of first and second clutches was 4.33 and 5.00 eggs, respectively. The earliest date of egg laying occurred April 18-23, about one month earlier than previously reported in the literature. In contrast, at sites nearby in Joshua Tree National Park, only one of eight females produced a clutch (five eggs), and she occupied the wettest microhabitat sampled that year. Most of the other monitored tortoises in the park occupied areas that were in the second year of drought with little or no production of annual food plants. Modest germination at the Mojave National Preserve allowed 12 of 18 monitored tortoises to produce single clutches (there were no subsequent clutches) in 1997. Differences among sites appear to be related to patterns of rainfall and annual biomass production, as expected.

Of particular interest is the fact that the average annual number of eggs produced per female at the Palm Springs site was more than double (8) that of tortoises at Mojave National Preserve (3.58). Such wide variation in annual reproductive output should be accounted for in any future population viability analyses for the species. Our results for 1997 have another aspect worth noting in that they underscore the fact that even well-protected natural areas like parks and preserves cannot protect sensitive species from the vagaries of climate variation. In this case, tortoises at a relatively wet and productive industrial site produced far more eggs than tortoises in fully protected, but drought-stricken, areas.

The results for 1998, an El Niño year, were remarkably different. At Palm Springs, 12 of 13 tortoises laid eggs and all 12 that produced eggs laid second clutches; about one-third produced triple clutches. Of interest is the fact that mean first and second clutch sizes did not differ from a statistical standpoint between 1997 and 1998 at Palm Springs. At Joshua Tree National Park, seven out of seven females laid eggs, and five produced second clutches. These differences with 1997 data seem to reflect the wet and highly productive conditions fostered by El Niño's rains. Rain that fell in late summer and early fall gave tortoises an opportunity to drink and feed on "summer" annuals prior to hibernation. Upon emergence from hibernation they were presented with a veritable cornucopia of winter annual food plants that germinated as a result of continued El Niño rains (fig. 4, page 24). Thus, to date our studies suggest that in years when tortoises have an abundance of food plants, more tortoises may reproduce and produce more clutches, but that they produce a relatively constant clutch size, regardless of conditions.

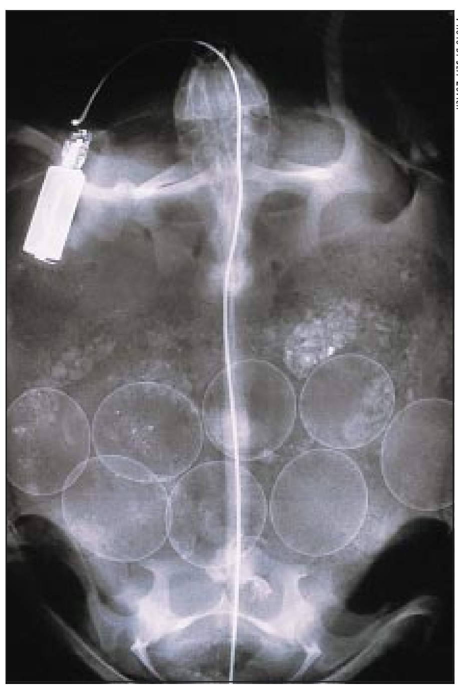
PHOTO BY JEFF LOVICH

Figure 3. This x-radiograph of a desert tortoise collected near Palm Springs (California) on 20 May 1997 clearly shows the outlines of eight shelled eggs. Females retain shelled eggs for 3-6 weeks prior to depositing them in nests. Nests are often constructed in the mouth of a tortoise burrow.

Future plans

The study will continue through the 1999 reproductive season at all five sites and through the 2000 season at Joshua Tree National Park and the site near Palm Springs. The data generated will provide natural resource managers with locally and regionally specific information on reproductive output of this threatened species and its relationship to environmental determinants such as rainfall and annual plant biomass production. Ultimately, these data can be used to build more accurate demographic models to better understand the recovery potential of desert tortoises.

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PHOTO BY KATHIE MEYER

Figure 4. In the spatially and temporally variable environment of the desert, resources such as rain and the annual plants that germinate in response to precipitation fluctuate widely. This photograph, taken in Joshua Tree National Park, shows how abundant annual plants can be in some years. In other years or places germination may be sparse or absent. Animals like the desert tortoise need strategies to cope with these large variations in productivity.

Phil Medica is a Research Wildlife Biologist with the USGS Biological Resources Division, and Station Leader of the Las Vegas Field Station, Las Vegas, Nevada. He has studied reptilian ecology for the past 30 years throughout the Southwest, the growth of desert tortoises at Rock Valley on the Nevada Test Site since 1967, and tortoise populations in southern Nevada on BLM lands for the past 10 years. He received a B.S. Degree in Wildlife Management in 1964, and an M.S. Degree in Biology (herpetology) in 1966 from New Mexico State University.

Hal Avery is a Research Wildlife Biologist at the Canyon Crest Field Station of USGS and has studied the reproductive biology of turtles since 1985. He has conducted research related to desert tortoise ecology and conservation since 1990 and is currently conducting research on ecosystem ecology in the Mojave Desert. He received his Ph.D. from the University of California, Los Angeles in 1998.

Alan Brown was a Wildlife Technician with the USGS Biological Resources Division at the Las Vegas Field Station, Las Vegas, Nevada. He assisted with desert tortoise density estimation studies conducted throughout the Mojave Desert (including the Mojave Preserve) between 1994 and 1997 as part of the Desert Tortoise Research Project, and participated in the desert tortoise reproduction study in the Mojave Preserve in 1997. He is completing his B.S. Degree in wildlife biology at the University of Montana, Missoula, Montana.

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Dwarf Shrew found in Rocky Mountain National Park

By Erin Muths

The dwarf shrew *(Sorex nanus)* is one of the smallest mammals in the world and is the smallest mammal in the southern Rocky Mountains (Armstrong 1987; Fitzgerald et. al 1994). Rocky Mountain National Park (Colorado) currently has no information of the dwarf shrew occurring in the park although Estes Park is the type locality (Armstrong 1987) for this species. The holotype was collected by E. A. Preble in 1895 at "Estes Park" and could easily have been taken at a location now within the park boundaries. Additionally, shrews have recently been suggested as potential bioindicators of environmental change and degradation by researchers at the University of Toronto (Ray 1998) and may provide important information for resource managers in this regard.

I found a dead dwarf shrew at Lake Husted (UTM zone 13; 448385E, 4484207W; 3,388 m; 11,116 ft) in the northeast corner of Rocky Mountain National Park on 17 July 1997. This specimen represents a new locality for *Sorex nanus* and is the first reported within Rocky Mountain National Park[1] (Jeff Connor, Rocky Mountain National Park, telephone conversation with author, 21 January 1999). Previously, the altitudinal record for *Sorex nanus* was 3,350 m (Hoffman and Pattie 1968; Hoffman, personal communication). This specimen was found 38 m (125 ft) higher, at the edge of Lake Husted in a mossy area surrounded by rocky glacial debris and low-lying juniper shrubs. The specimen was intact except for a small hole in its skull. I measured its total length, tail length, and hind foot length and examined the skull in the laboratory.

The shrew had brown fur dorsally with a lighter underbelly and measured < 90 mm (3.5 in) total length. Its tail was 40 mm (1.6 in), and its hind foot was 12 mm (0.5 in). The carcass weighed approximately 2.5 g (< 0.1 oz) but was considerably decayed when weighed. From these measurements, I determined the specimen to be *Sorex nanus*. The specimen was also examined by D. Armstrong (University of Colorado) and compared to a confirmed *Sorex monticolus* specimen; this shrew was smaller in all dimensions. Based on measurements and direct comparison my identification as *Sorex nanus* was confirmed.

Dwarf shrews are primarily montane in distribution and have been collected from rock slides and spruce-fir bogs (Brown 1967), alpine tundra (Hoffman and Taber 1960; Hoffmann and Pattie 1967), and marsh and forest clear-cut (Spencer and Pettus 1966). Hoffmann and Owen (1980) report an altitudinal range of "at least" 740-3,350 m (2,428-10,991 ft). Although the carcass appeared intact and essentially undisturbed, it is possible that the shrew was carried to the site by a bird and dropped, but this could not be confirmed.

Rocky Mountain National Park has listed the dwarf shrew in its Resource Management Plan (USDI National Park Service 1998), but the project is currently unfunded. When funding is obtained, potential projects might include a simple determination of the abundance and distribution of the dwarf shrew in the park to provide baseline data for monitoring population trends; studies of the habitat requirements of the shrew; studies of predator-prey interactions, and the potential for visitor impacts on the shrew.

As more people travel into the backcountry risks associated with human disturbance clearly increase. Even low volume human activity at higher elevations can have profound effects on the delicate alpine tundra plant communities and may have related effects on small mammals, such as the shrew, which may use these ecosystems exclusively. Shrews exist within very small areas that must sustain them throughout their lives. Even small disturbances of fragile ecosystems have the potential to disrupt individuals and perhaps to disrupt entire populations of shrews.

[1]A dwarf shrew was documented in 1967 for Larimer County, Colorado, just north of the park (Jeff Connor, Rocky Mountain National Park, telephone conversation with author, 21 January 1999).

Acknowledgments

Thanks to Dave Armstrong, University of Colorado, for help with identification; Therese Johnson, Craig Axtell, and Jeff Connor at Rocky Mountain National Park and Steve Corn, USGS Biological Resources Division, for encouragement and support. PS

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Fig. 1. Old logging roads, such as this one in Whiskeytown National Recreation Area (California), are the primary source of sediment that washes into rivers and streams, degrading habitat for salmon and steelhead trout. To address the problem, the park and Shasta College teamed up to deploy innovative treatments for the restoration of watersheds and habitat recovery. This road was "outsloped[1]" to reduce erosion and sedimentation.

Cooperative watershed restoration in Whiskeytown National Recreation Area

Innovative partnership provides a model for restoration of a scarred landscape

By John McCullah and Gretchen Ring

Salmonid fisheries continue to decline in the Pacific Northwest. As a result, more populations of salmon and steelhead trout continue to be listed as endangered or threatened. A primary cause of this decline is loss of habitat due to impacts from upland erosion and sedimentation.

In many steep, forested watersheds old logging roads (fig. 1) are the primary source of the sediment that degrades rivers and streams. Roads cause erosion and greatly increase the potential for slope failure during large and episodic storm events. Roads alter the natural drainage patterns, and steeply cut slopes intercept subsurface flows, converting them to surface runoff. Drainage ditches and berms concentrate flows in channels, efficiently delivering sediment to streams. Most importantly, roads are frequently constructed by placing fill material in drainage channels. That fill becomes part of the drainage system and, given enough time, has a high probability of ending up in rivers and streams. Clearly, watershed restoration strategies are needed to deal specifically with road-related erosion and sedimentation.

The Whiskeytown situation

Located 8 miles west of Redding, California, Whiskeytown National Recreation Area primarily occupies the Clear Creek watershed, an important tributary to the Sacramento River. With a history of past logging, this unit of the national park system has experienced many erosion and sedimentation problems. For example, roads were constructed by placing fill in runoff channels, which alters the natural drainage patterns and basin hydrology, and increases the potential for stream diversions and washouts. Poor road drainage and saturated fill can result in severe landslides. Two large debris flows in the park were initiated at the intersection of stream channels and roads during heavy rains in January 1997.

Solutions to these problems require specially trained watershed restorers such as geomorphologists and heavy equipment operators to identify and treat the numerous watersheds impacted by roads. The National Park Service is addressing these issues at Whiskeytown by cooperatively engaging in ecosystem restoration activities and encouraging education and technology transfer related to these experiences.

Cooperative agreement

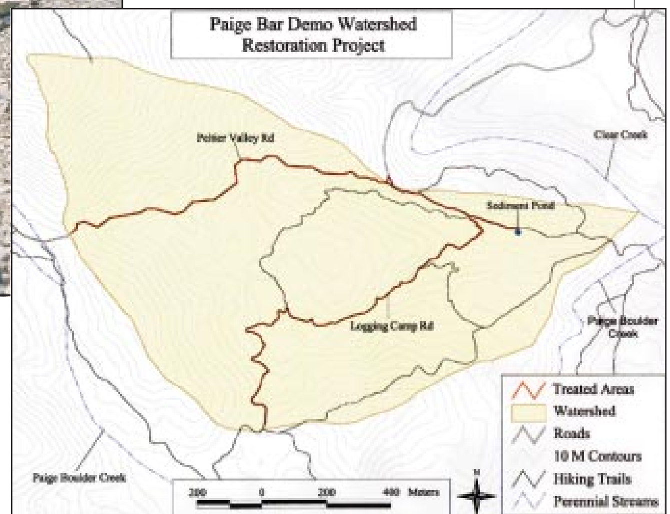
In 1996, Whiskeytown and Shasta College entered into a cooperative agreement that enables them to share resources, including funds, for the completion of mutually beneficial projects, primarily watershed restoration. The cooperative restoration program blends education with technology and encourages adaptive management and the use of innovative techniques to treat habitat degradation in the park caused by old roads. Furthermore, it trains students in restoration ecology, provides a potential employment venue for former timber workers, and improves habitat for salmon populations.

The park serves as a living laboratory in which students conduct actual watershed inventories, develop restoration techniques, engage in monitoring activities, and implement restoration plans. Shasta College provides expertise in various disciplines such as geographic information systems (GIS), watershed restoration, heavy equipment operation, and horticulture; a student workforce performs the work. As part of the agreement, Shasta College developed a watershed restoration class to prepare students for jobs in ecosystem management with practical experience coming from a pilot restoration project at the park. The class emphasizes the geomorphic or landform restoration approach to ecosystem restoration. The pilot sub-watershed restoration project was funded by the Bureau

[1]In hilly terrain, roads typically slope inward toward the hill where a ditch and culvert system drains runoff. As culverts and ditches become plugged, runoff concentrates, drains across the road, and creates gullies. Outsloping reverses drainage to the downhill side of the road. Fill is excavated and placed into the uphill cut, resulting in a 2-5-degree slope to the downhill side. Water runs off without forming gullies and subsequent erosion and sedimentation.

Fig. 2 (left). Heavy equipment is used to treat the drainage problems posed by the old logging roads. Here, a culvert is installed to restore natural drainage patterns and reduce erosion of the fill.

Fig. 3 (below). The 300-acre Paige-Bar subwatershed was the site of the demonstration restoration project at Whiskeytown. The project represents a significant start to the many thousands of acres of Clear Creek watershed in need of restoration at the national recreation area.



of Reclamation ($40,000) through the Central Valley Improvement Act, and by the National Park Service through a Challenge Cost-Share Grant ($30,000).

Goals and treatment philosophy

The restoration goals for Whiskeytown National Recreation Area include restoring naturally functioning ecosystems by treating and removing scars on the landscape such as roads. Other management tools, such as prescribed fire and exotic plant removal, can then be employed to enhance biodiversity.

Previous restoration work and studies in Redwood National Park (Spreiter 1994) and Grass Valley Creek Watershed (McCullah 1994) indicate that the primary source of erosion and cause of sedimentation of streams is the extensive road network left over from past logging. These projects clearly demonstrate that physical treatments to restore the hydrologic systems, recover soil from stream channels, and remove road scars set the stage for recovery of the biological systems, and these methods are probably the most cost-effective way to prevent erosion and sedimentation, and reduce the maintenance burden.

These physical treatments frequently include the use of heavy equipment such as hydraulic excavators (fig. 2) and bulldozers to repair and restore the drainage patterns that existed before roads were built. A new axiom is emerging among watershed restorers: for cost-effective road restoration, employ the same type and size of equipment that caused the problem. The key to cost-effective sediment reduction, however, is prevention, not treatment of what already happened. Erosion inventories, therefore, must evaluate all existing and potential problems along roads and document the amount of erosion that may potentially occur, particularly at road and stream crossings.

The demonstration project

The 120-ha (300-acre) Paige-Bar sub-watershed (fig. 3) was chosen as the demonstration pilot project. It is located in the lower Clear Creek watershed near the Whiskeytown National Environmental Education Development Camp. Proximity to the camp is significant in that 3,000 fifth and sixth graders visit it every year and see the restoration work that has been accomplished as part of their restoration education. The site was extensively logged in the 1960s and most recently in 1973, just before NPS acquisition of the lands. Approximately 2 km (1.2 mi) of main-use road (Peltier Valley Road) and several kilometers of old haul roads, including the badly eroded Logging Camp Road, exist on the site. These old roads are currently used for recreation, primarily hiking, mountain biking, and horseback riding. Additionally, numerous old landings built in the stream channels are eroding and producing sediment.

For cost-effective road restoration, employ the same type and size of equipment that caused the problem

Inventory

Before beginning field inventories, students from the Shasta College Watershed Restoration class drew the entire microdrainage network of the Paige-Bar subwatershed onto a 7.5-minute topographical map. They also delineated roads and streams on clear mylar, laying it over aerial photos and orthophotos. Both recent and older stereo aerial photos were studied in order to identify eroding sediment sources; erosion is often hidden by dense vegetation but may be clearly visible in photos taken immediately after a disturbance. Historic aerial photo analysis is an efficient way to become thoroughly familiar with the drainage network, history of road construction, timber harvest, and other disturbances.

See "Whiskeytown" on page 28

"Whiskeytown" continued from page 27

The inventory work was completed in the summer and fall of 1996. During this phase groups of students worked as an interdisciplinary team, inventorying the landforms and exploring answers to the question, "why is the landscape like this?" The geomorphic perspective is especially important; therefore, the students were given some training in geology and fluvial processes. As part of their training, they toured the nearby Grass Valley Creek watershed to evaluate the efficacy of the treatments used there.

The students developed inventory forms based on advice from Redwood National Park geologists. Their strategy divided the inventory into two distinct areas: the *site* where the road crosses a drainage and the *road segment* between two sites. Consequently, the road erosion inventory form featured a section for sites (swale or stream crossings) and a section for road segments. As the teams inventoried the road, they filled out the appropriate section of the form. Photographs were taken of each site or segment. Road condition, accessibility, width, and length were also noted and recorded on the data sheet.

Data were collected for the sites, including the type of site, i.e., stream crossing, headwater swale crossing, spring, crossroad drain, or other. The amount of fill in the site was estimated as an order of magnitude ranging from "small" (1-5 m^3; 1.3-6.5 yd^3) to "extra-large" (greater than 50 m^3; 65 yd^3). Potential for future erosion was evaluated and treatments recommended. Possible treatments for sites included a shallow dip (10% of the fill removed), culvert replacement (see fig. 2, previous page), a large dip (50% of the fill removed), or complete crossing removal (100% of the fill removed). Justifications for the treatment recommendations were also recorded. Students also collected data for the road segments. The amount of fill in the road was estimated, and the potential for future erosion was assessed as high, moderate, or low. Based on this information a potential treatment was recommended for segments. Possible treatments included outslope, outslope with rolling dip, or recontour (partial or complete road removal).

The information collected was entered into a database and linked to a GIS. The Shasta College engineering and GIS students got involved at this point and developed GIS maps; thus, the attributes for each site and segment could be queried using ArcInfo software. A total of 27 sites and 29 segments were identified on Peltier Valley Road; 31 sites and 19 segments were identified on Logging Camp Road. Segments and sites and the degree of erosion potential for each road are listed in Tables 1 & 2.

Table 1. Summary of Segments and Sites on Peltier Valley Road

Type	Number	Erosion Potential
Road segments	5 segments	High
Road segments	16 segments	Moderate
Road segments	8 segments	Low
Stream crossings	15 crossings	High
Stream crossings	1 crossing	Low
Swale crossings	5 crossings	High
Headwater	1 headwater	Low
Skid trails	2 trails	High
Springs	2 springs	Moderate
Other	1 culvert pull	Moderate
Springs	1 spring	Moderate
Other	1 slump	High

Table 2. Summary of Segments and Sites on Logging Camp Road

Type	Number	Erosion Potential
Road segments	11 segments	High
Road segments	7 segments	Moderate
Road segments	1 segment	Low
Stream crossings	12 crossings	High
Stream crossings	2 crossings	Moderate
Swale crossings	2 crossings	High
Swale crossings	2 crossings	Moderate
Skid trails	9 trails	High

Project design & implementation

Peltier Valley Road

The watershed restoration students completed designs and prepared implementation plans for work on Peltier Valley Road based on the existing and potential problems identified in the inventory. The work was performed by the Watershed Restoration class and the Heavy Equipment Operations class. Shasta College also contracted the services of a heavy equipment operator with restoration experience in Redwood National Park and Grass Valley Creek watershed. The heavy equipment consultant provided on-site supervision and demonstrated equipment use. Altogether, Shasta College performed the following work on Peltier Valley Road:

1. Reconstructed approximately 2,000 m (1.2 mi) of the Peltier Valley Road using outsloped road design
2. Excavated rolling dips at each of the 23 swale and stream crossings
3. Replaced or installed seven appropriately sized and redesigned culvert crossings to reduce erosion
4. Treated all disturbed soil by seeding with native grasses and mulching

Sediment pond

Using remnants of an old logging road as an embankment, the students designed and constructed a sediment pond in the lower reaches of the watershed. The pond is used to monitor and measure sediment production before and after treatment. The drainages of both the Peltier Valley Road and Logging Camp Road converge at the location chosen for the sediment pond. The pond has an expected life of three years after which it and the old road will be removed and the stream returned to its natural course.

The pond weir was constructed with layers of continuous berm (fig. 4) stacked in a triangular shape. MBW, Inc., donated the use of their Continuous Berm Machine and demonstrated its use. This machine can encapsulate soil, sand, or rock in filter fabric to make a berm that is 0.4 m high by 0.3 m wide (~1.3 ft x 1.0 ft). In this situation the berm was filled with existing channel material; no nonnative sediment was introduced to the stream. The berms conform tightly to the stream bottom because they are very heavy with a density of 1,600 kg/m^3 (2,691 lb/yd^3). The berms can be

Fig. 4. A sediment pond was constructed within the lower reaches of the watershed to monitor erosion before and after restoration work. After three years, it will be removed and the stream restored to its natural course.

stacked much steeper than the angle of repose without slumping, and they can be used as spillway weirs without stream erosion because of the support provided by the fabric (Ellis 1997). The continuous berms were reinforced by driving willow stakes through the fabric.

The sediment pond has performed well. The weir has been through a number of rainstorms and it has been subjected to a variety of flows. The vegetation around the pond is well established. The willows planted within the berms have achieved heights of over 2 m (6.6 ft) and are rooting both inside and below the berms.

Logging Camp Road

As already mentioned, Whiskeytown and Shasta College received a $30,000 Challenge Cost-Share Grant from the National Park Service in 1997. This grant funded removal of the Logging Camp Road. Although the road was decommissioned, a single-track, multiuse trail was left in its place. Stream crossings have been completely excavated and recontoured (except for the trail) by pulling back all fill.

The Shasta College Watershed Restoration class supervised the work. The Heavy Equipment Operation class and the experienced heavy equipment consultant performed the work, which was completed in October 1998. Costs associated with complete road removal were closely monitored, and the sediment pond facilitated erosion monitoring during the construction activities.

Conclusion

This pilot project provided an invaluable opportunity for the National Park Service to work with Shasta College in further developing watershed restoration strategies for Whiskeytown National Recreation Area. Park staff participated in the Watershed Restoration class and worked alongside students in inventorying the roads and developing treatment plans. Grant funding from the National Park Service and the Bureau of Reclamation (total of $70,000) allowed the students to perform actual roadwork that will benefit the Sacramento River fisheries. Our experience gained in this cooperative, pilot restoration project holds great potential as a model for erosion and sediment source inventories, watershed restoration designs, and road treatments for use by the multiple federal, state, and local agencies now involved in restoration activities in the Clear Creek and Sacramento River watersheds. PS

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RICHARD D. ALLEN

Figure 1. Named for its large, inflatable snout, the elephant seal (male shown here) is making a pronounced comeback at Point Reyes National Seashore. Colonization of the seashore began in the early 1970s with a breeding colony first noted in 1981. The park is monitoring the growth of the population, estimated at 1,500 in 1998.

Mirounga massing at Point Reyes

BY SARAH G. ALLEN

While exploring tide pools at a remote area at Point Reyes Headland, park rangers discovered a female elephant seal and pup in 1981. From that first birth, a colony grew and swelled in number over 15 years with nearly 400 pups born in 1998. They are a challenging addition for Point Reyes National Seashore (California), though, as the park is visited by more than two million humans annually. The park is currently developing a strategy for protecting and managing elephant seals by gathering sufficient information on seal habitat needs and potential conflicts.

Elephant seals of the genus *Mirounga* are the largest in size of all pinnipeds of the world. The term *Mirounga* is derived from an Australian aboriginal name for the elephant seals and represents two species in the genus; the northern species *(Mirounga angustirostris)* is of the northern latitudes. The name "elephant seal" derives from the large inflatable snout of the male (fig. 1). They rely on a thick layer of subcutaneous fat for insulation and use this fat for energy when fasting onshore for long periods. Females lack the large nose and are much smaller in size. Elephant seals weigh up to 2,300 kg (3,000-5,000 lb) and tend to be around 380-410 cm (12-14 ft) in length, whereas females weigh 600-800 kg (1,320-1,760 lb) and are 280-300 cm (9-10 ft) long. The life span of elephant seals is poorly studied but the oldest female whose age is known at Point Reyes Headlands was 21 years.

Charles Scammon, a British seal hunter who explored and exploited the Pacific coast in the 1800s, recorded that northern elephant seals were distributed from Cabo San Lazaro, Baja, Mexico, to Point Reyes, California. By the turn of the century, elephant seals nearly were extinct because sealers hunted them for the high quality oil that could be produced from their blubber; one bull elephant seal could yield nearly 25 gallons of oil.

With protection provided first by the Mexican government on Isla Guadalupe and later by the United States on the Channel Islands, California, the population recovered at an astounding rate, growing an estimated 6-8% per year. As the colony grew, seals began colonizing new sites, expanding northward. Pups were first seen on San Miguel Island, California, in 1957. From a low count of only a few hundred animals in the 1890s, the worldwide population has grown in 100 years to around 150,000.

Colonization of Point Reyes

Point Reyes is just one of around 11 breeding sites for this species along the eastern Pacific rim and until the mid 1990s was the most northern. Colonization of Point Reyes began in the early 1970s when individual animals were sighted with increasing frequency. Then in 1981, a breeding colony formed at Point Reyes Headland when a pup was seen with a female and attended by an adult male. The colony was situated in an inaccessible pocket beach at the base of a steep cliff. Since then, the colony has grown exponentially. In 1998, the estimated number was around 1,500.

The park has monitored the growth of the colony with weekly surveys, flipper-tagging individuals, and monitoring human interactions with remote camera. During winter 1994-95 and the El Niño of 1998, severe storms and high tides (aggravated by the elevated sea level of the El Niño) pummeled the pocket beach where the main colony congregates. Many pregnant females were unable to find space for birthing in the midst of these storms and a few selected alternative beaches at Point Reyes with its relatively tranquil waters and ample space. These new subcolonies were revisited annually since then, indicating that the colony is spreading.

Annual cycle

Elephant seals congregate onshore at these terrestrial colony sites three times per year, but the total numbers and proportion of various age and sex categories varies per season: the breeding season (December-March), the molt (March-July), and the juvenile haul out (September-November). During the rest of the year (nearly 80%), the seals are entirely pelagic, living only in the ocean

Elephant seals have a hierarchical breeding system with large dominant males aggressively defending their position near

Richard D. Allen

Figure 2. With numbers on the rise at Point Reyes, elephant seals are overflowing onto publicly accessible beaches. Resource managers now have several considerations to balance along with species recovery: public safety, wildlife harassment, transmission of diseases between seals and dogs and cattle, and disruption of colonization at new beaches.

groups of females. Females begin pupping within a few days of their arrival with the first pup born around mid-November. Small discrete colonies such as the Point Reyes Headland colony may have only a few dominant bulls, whereas large, continuous colonies such as the San Miguel Island colony may have an array of bulls and subordinate males at intervals along a beach.

Females usually give birth to a single pup, weighing around 32 kg (70 lb) and displaying a black coat of fur. Pups cannot swim at birth, and consequently, are vulnerable to storms and disturbance. Mortality rates of pups have been low most years at Point Reyes Headland, but with increased density coupled with severe storms as occurred in 1992, 1995, and 1998, the survival of pups decreased. In 1995, survival was only around 45% and only around 25% in 1998.

Marine habitats

Elephant seals spend 60-80% of their time at sea, but little is known about their distribution or behavior at sea. In recent years, though, new technology in the form of satellite tags and time-depth recorders has enabled researchers to discover that elephant seals can dive up to one mile deep and stay under water for almost two hours. Elephant seals disperse rapidly and widely from the colonies; one elephant seal tagged at San Miguel Island, for example, was located in the Bering Sea within two weeks. They range west as far as 173°W longitude, beyond the Hawaiian Islands, and north to the Bering Sea and eastern Aleutians. In the Gulf of the Farallones, we have correlated elephant seal distribution with deep waters off the continental shelf. The most current information on the diet of elephant seals indicates that they forage in the midwater zones, likely eating cephalopods and Pacific hake, although seals are also known to prey on skates, rays, sharks, shrimp, and crab.

Elephant seals are in turn preyed upon by primarily the great white shark *(Carcharodon carcharias)*. Point Reyes Bird Observatory biologists on the Farallon Islands estimate that around 10% of the elephant seal population is preyed upon annually by great white sharks. Many incidences of shark attacks on seals and sea lions have been observed at Point Reyes Headland by park personnel over the past decade.

Management issues

The arrival of elephant seals at Point Reyes is an extraordinary example of the benefits of simple protective measures like the Marine Mammal Protection Act; however, now many land management agencies such as the National Park Service are faced with several new issues. The main colony was inaccessible, but with crowding, the colony began to overflow onto three nearby beaches, two of which are accessible to park visitors (fig. 2).

Issues that surfaced since 1995 include public safety from seals, harassment of seals by park visitors, potential disease transmission between seals and dogs and cattle, and disruption or deterrence of colonization at new beaches. Park docents logged 880 hours over 35 days of educating visitors during weekends and holidays, and on nearly 30% of these days, people were observed harassing seals. Most pinnipeds on land react to the approach of humans (especially with dogs) and will stampede into the water when approached too closely. Behavioral changes, such as retreating into the water or cessation of nursing activity, are defined as disturbance under the Marine Mammal Protection Act. At newly established colonies, human presence can deter pregnant females from pupping on beaches. Of additional concern is the transmission of serious diseases (e.g., canine distemper) from dogs to seals, and the National Marine Fisheries Service recommends that dogs be prohibited on beaches where pinnipeds occur.

Safety issues are of concern from both direct and indirect encounters with seals. Elephant seals are known to chase and bite people when seals are approached too closely. This is of special concern during the breeding season when male seals are fighting and females are defending their young. Because elephant seals are a favored prey item of great white sharks, there is concern that the visiting public may be at greater risk while boating or swimming in Point Reyes waters around seal haul out sites; the region has one of the highest incidence rates of white shark attacks on people in the world.

The park produced an elephant seal management plan to address the myriad of issues associated with the seal colony expansion. Some additional long-term potential conflicts include impact of elephant seals to other resources in the park such as the western snowy plover *(Charadrius alexandrinus nivosus)*, which was listed as a threatened species by the U.S. Fish and Wildlife Service in 1993 and several rare native plants in the coastal dune community.

Elephant seals are a heroic species that exemplifies the remarkable recovery of a species given simple protective measures; they are also impressive and fascinating to the visiting public. The task of the park is to strike a balance between enabling the elephant seal colony to continue to recover and responding to the visitor interest. Beginning in 1996, the park initiated a docent program to educate visitors and protect seals; a total 33-45 volunteers interacted with visitors and collected data. This coming year, the program will be expanded, as will research on the colony as we attempt to discern why seals choose some beaches over others for breeding. PS

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"Real-time" air quality monitoring data displayed at Great Smoky Mountains

By Dee Morse, John Ray, and Jim Renfro

In Great Smoky Mountains National Park (Tennessee and North Carolina), air pollution seriously damages park resources. Visibility is impaired by a uniform haze that affects scenic vistas. Landscape features and colors fade, diminishing the experience of visitors to the park. Air pollution in the form of ground-level ozone threatens human health and vegetation. A variety of plant species (black cherry, yellow poplar, sassafras, tall milkweed, and cutleaf coneflower) show symptoms of ozone injury to foliage. Other airborne pollutants, including sulfur and nitrogen compounds, result in acidification of some high-elevation streams, soils, and plants.

Data collection for the assessment of air pollution impacts on resources in national parks has been successful in addressing this resource management concern. Public awareness, however, should not be underestimated as a partner to science as an effective means of protecting park air resources. An informed public can be a strong ally in these efforts. Now, using modern communication methods, computer exhibits can show visitors real-time visibility, air pollution concentrations, and weather conditions.

Real-time data exhibited

Currently, Great Smoky Mountains National Park is using real-time visibility data in an interpretive exhibit on air quality at the Sugarlands Visitor Center. Park Superintendent Karen Wade is excited about the exhibit. "It is important for the public to understand how air pollution affects park resources, since the public plays a key role in bringing about those actions necessary to prevent air pollution impacts," Wade said. "The park should use the best information and tools available to increase public awareness."

The exhibit at Sugarlands Visitor Center consists of two 3 ft x 9 ft panels located in the visitor center. The panels display information about the cause and effect of air pollution at the park (fig. 1). Monitors in each panel are linked to air monitoring equipment at the park's Look Rock air quality station and observation tower and show current visibility, ozone concentrations, and meteorological conditions. An air quality brochure is also available at the visitor center for individuals who would like more in-depth information about air pollution impacts at the park.

Figure 1. The interpretive exhibit inside the Sugarlands Visitor Center describes the air quality condition at the park, displays photos comparing good (100 miles +), bad (~20 miles), and current visibility images at Look Rock, and features ozone and meteorological data that are updated every 15 minutes.

At Look Rock, a digital zoom camera captures visibility images (fig. 2), a nephelometer gathers optical visibility data, an ozone analyzer measures ozone concentrations, and meteorological monitoring equipment collects weather-related information (fig. 3). The digital camera, mounted atop Look Rock observation tower, is aimed toward the crest of the Great Smoky Mountains to capture images characteristic of the park and familiar to visitors. The camera is equipped with a personal computer modem. The camera and support computer, housed in a secure, environmentally controlled enclosure, have the following capabilities:

Figure 2. Capturing a new visibility image every 15 minutes, the digital camera is mounted inside the observation tower at Look Rock. The digital image is transmitted by telephone line and short-haul modem to the Look Rock air quality shelter (right).

Figure 3 (below). Instruments at Look Rock record weather data, measure ozone, and analyze visibility distance (visual range). A data logger collects the information and forwards it to Sugarlands Visitor Center.

1. Acquisition of a digital image at selected time intervals
2. Automatic light-level and color-balance adjustment
3. Image capture across a wide dynamic range
4. User-selectable camera field of view
5. Off-site reconfiguration and reset capabilities
6 Reliable operation over a wide ambient temperature range

The digital image is transmitted by telephone line and short-haul modem to the Look Rock air quality shelter. There, a data logger and computer record measurements from the nephelometer, ozone analyzer, and meteorological sensors. Data are sent every 15 minutes through a telephone line to a computer at Sugarlands Visitor Center and to a local Internet service provider in Knoxville, Tennessee. The visitor center computer performs the following functions:

1. Acquires image and data files
2. Validates the data and image files
3. Formats the image and data files for display on exhibit monitors
4. Cycles visitor display screens
5. Provides for on- and off-site modifications of the display programs
6. Provides for on- and off-site system troubleshooting

The computer operates a Windows-based program that is easy to use. Park staff can troubleshoot individual computer system components and change the displayed information. The staff have dial-up computer access to the digital camera and to the data logger to make changes in operational modes, reboot the camera computer, or conduct troubleshooting activities.

On each of the 21-inch monitors in the exhibit, three different display screens are cycled for the public to view. One screen provides a current video image from Look Rock and information on current visibility conditions (fig. 4), shown as visual range in miles. Static images of a good visibility day and a typical day (i.e., the current seasonal average) are also presented on the screen, inviting comparisons with current visibility conditions. A second screen provides information about current ozone concentrations at Look Rock. The current hourly concentration is displayed on the screen along with the previous day's maximum and minimum hourly ozone concentrations. In the lower half of the screen, a static scale shows public health-related effects from ozone. A third screen provides meteorological information from Look Rock. This includes current wind direction and speed, ambient temperature, relative humidity, and precipitation.

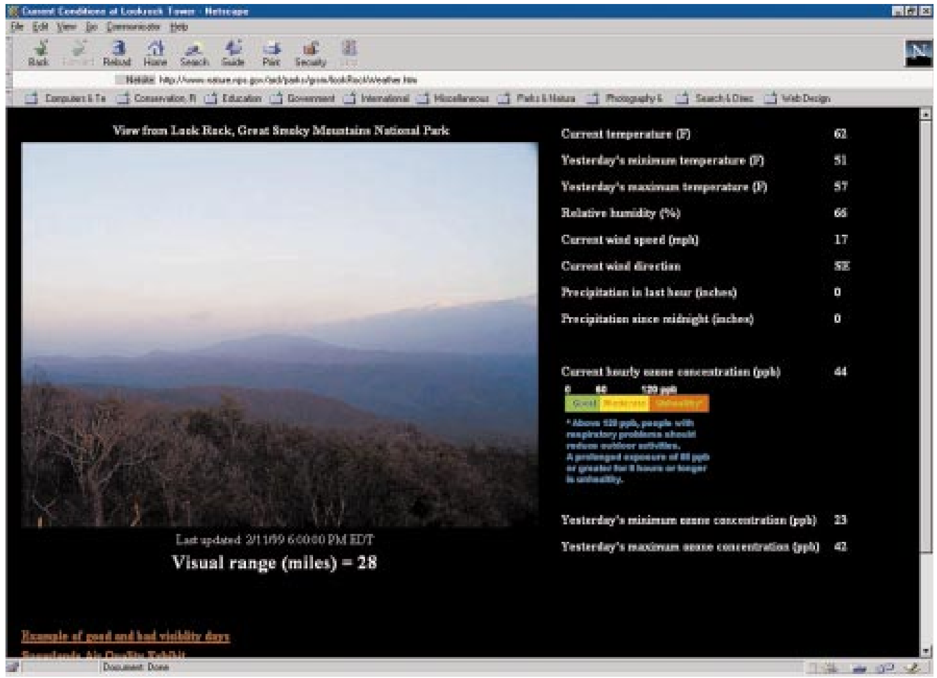

Figure 4. A "real-time" photograph of the view from the Look Rock observation tower is published on the World Wide Web every 15 minutes. The caption documents the time when the image was made and the visual range depicted in the scene. Meteorological data including temperature, relative humidity, precipitation, and wind speed and direction are updated every 15 minutes. Ozone concentrations are updated hourly.

First on the Web

The real-time interpretive air quality exhibit at Sugarlands is also the first exhibit of its kind to present current monitoring data in a national park on the World Wide Web. The information from Look Rock is sent via the Internet to the Air Resources Division in Denver, Colorado. There it is published on the World Wide Web at *www.nature.nps.gov/ard/parks/grsm/lookRockWeather.htm.*

The technology used for this exhibit can also be used to present monitoring data from a variety of other natural resource management activities in a park. This interpretive approach serves as a very effective resource management tool. The presentation of real-time monitoring data not only enables park managers to provide the public with current data, but it also provides an opportunity to easily modify and update the presentation of data results.

Funding for the exhibit and its link to the monitoring equipment was provided through a partnership with the NPS Air Resources Division, U.S. Environmental Protection Agency, Great Smoky Mountains Natural History Association, and Great Smoky Mountains National Park.

The total cost for this project at Great Smoky Mountains National Park was approximately $50,000. The cost, however, was unique to the monitoring setup at the park and may be approximately the same or lower at other units of the national park system, depending on configuration and location of the monitoring equipment. The Air Resources Division has limited funds available each fiscal year to assist with the development of real-time exhibits in units that are monitoring air quality parameters. PS

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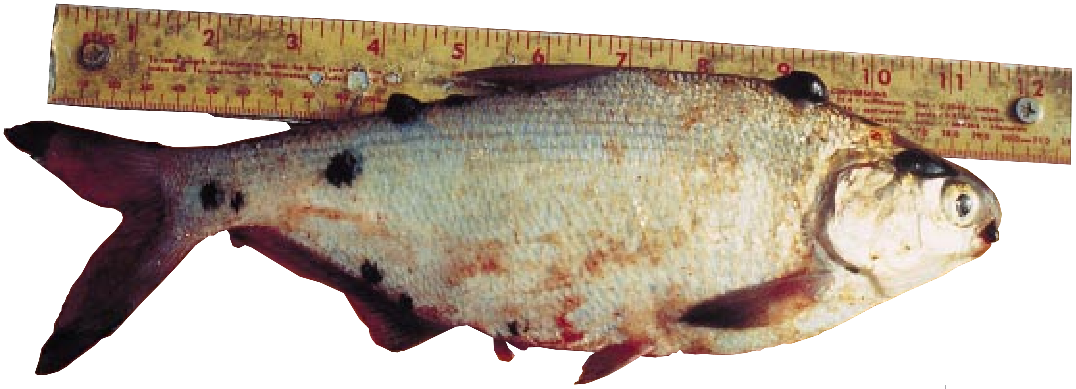

Figure 1. An adult gizzard shad exhibiting multiple raised black tumors.

Persistent expression of tumors in Lake of the Arbuckles gizzard shad

A summary of eight years of study

BY GARY K. OSTRANDER, RON PARKER, AND WILLIAM E. HAWKINS

During the spring of 1991, while conducting studies on the health of fishes in various lakes and rivers in Oklahoma (e.g., Kuehn et al. 1995), we were asked to investigate reports of large black tumors appearing on the skin of gizzard shad *(Dorosoma cepedianum*–fig. 1). The shad were collected from a lake within Chickasaw National Recreation Area in south-central Oklahoma. The Lake of the Arbuckles is a 2,350-acre reservoir fed by Guy Sandy Creek, Buckhorn Creek, Rock Creek, and its tributary, Travertine Creek (fig. 2). The lake has a mean depth of 9 m (~30 ft) and 58 km (36 mi) of shoreline. In 1996, the park recorded more than 70,000+ boater visits and approximately 20,000 boats on the lake with most visitors participating in sport fishing activities. The primary sport fish within the recreation area include largemouth, smallmouth, and spotted bass; crappie; channel catfish; and sunfish. The incidence of tumors on gizzard shad is of concern because the species is a forage fish in Lake of the Arbuckles, the park's largest aquatic resource, and it is unexplained.

Construction and filling of the Lake of the Arbuckles was completed in 1967 and nothing in its history suggests any significant contamination could be responsible for tumors appearing in the fish. Nonetheless, we began a comprehensive study in August of 1991 with the ongoing objective of determining the nature and extent of the lesions appearing in the gizzard shad residing in the lake.

Malignant tumors documented

The initial survey of Lake of the Arbuckles revealed that 14 of 105 gizzard shad collected exhibited one or more raised black lesions. Grossly, the lesions were primarily distributed over the head, trunk, and fins as superficial raised masses that were almost always darkly pigmented (see fig. 1) and ranged in size from 0.1 to >2.0 cm (0.04-0.79 in) in diameter. The lesions were ultimately diagnosed as subcutaneous spindle cell tumors that most likely arose from the cells that surround nerves or from pigment cells (Ostrander et al. 1995).

Subsequent surveys of the lake (1991-96) and the collection of over 1,200 adult and at least 2,000 juvenile shad have revealed that at any one time approximately 20% of the adult shad (>1 year) exhibit one or more tumors. To date, tumors have not been seen in any of the juvenile shad that we have examined. The significance of these observations lies in the fact that fish exhibiting tumors in 1996 were not present when the lesions were first discovered in 1991; thus, whatever is responsible for the formation of the tumors is still exerting its effect today.

What is causing the tumors?

Once the diagnosis of malignant cancerous tumors in the gizzard shad was made, the focus of our efforts shifted to attempting to determine the cause. Cancer in fishes has been previously reported at various locations in North America (e.g., Puget Sound, Boston Harbor, The Great Lakes), but never in a national park (reviewed in Harshbarger and Clark 1990). Typically, tumor-bearing fish populations are found in areas high in human-caused pollution with aromatic hydrocarbons (e.g., fossil fuels) or heavy metals most often being implicated; thus, our initial studies focused on the analysis of the water and sediments of the Lake of the Arbuckles. Water and sediment samples were collected from a variety of locations and subjected to gas chromatography-mass spectrometry. The resulting spectra were matched to an online library of 44,000 environmental contaminants. No significant matches were found. Likewise, analysis of water, sediment, and shad tissue samples did not reveal significant levels of chromium, nickel, lead, cadmium, or copper–all previously implicated in tumor formation in other vertebrates, including humans. Finally, we used inductively coupled plasma mass spectrometry to determine if significant levels of 64 trace elements (e.g., arsenic, selenium, mercury, etc.) correlated with the high levels of tumors seen in the gizzard shad. Again, no significant increase in any of these elements was observed (Ostrander et al. 1995, Jacobs and Ostrander 1995).

The region around the Lake of the Arbuckles is the site of natural deposits of uranium and as such we explored the hypothesis that elevated levels of radioactive uranium or its by-product radon gas could be contributing to the high tumor incidence seen in the Lake of the Arbuckles. Water samples were collected from Lake of the Arbuckles and Lake Carl Blackwell and analyzed for gross alpha/beta and radon-222 radiation. Lake Carl Blackwell is also located in central Oklahoma and contains a large population of tumor-free shad. As with the other chemical analyses, no increase in the background levels of uranium, total radioactivity, or radon were observed. Moreover, no differences were noted between the two lakes (Geter et al. 1998).

Figure 2. Map of south-central Oklahoma and northern Texas illustrating sampling sites. Lake of the Arbuckles is within Chickasaw National Recreation Area.

According to earlier research, viruses can cause tumors in fish and other organisms. Among fishes, at least two examples of tumors similar to what we are observing in the Lake of the Arbuckles have been linked to retroviruses (discussed in Ostrander et al. 1995). Our laboratory developed a test for the assessment of a retroviral cause of these tumors. Examination of the tumors for reverse transcriptase, an enzyme indicative of the presence of a retrovirus, was negative. Likewise, analysis of the tumors by electron microscopy failed to reveal the presence of any retroviral or other viral particles. Along these same lines, the occurrence of tumors was not seasonal as often is the case with virally induced cancers in feral fish population (Ostrander et al. 1995).

We have also investigated the possibility that tumors in the gizzard shad may arise from only a certain segment of the population. That is, it is reasonable to hypothesize that if restricted interbreeding was occurring within a segment of the population the tumor phenotype could be carried through successive generations. The mechanism for such an occurrence has been previously identified in fish and humans. The best studied example is the occurrence of melanomas in laboratory populations of *Xiphophorus* (swordtails and platys–fish that bear live offspring) that are caused by the altered expression of a tumor suppressor gene (reviewed in Ostrander and Blair 1997). Altered expression of tumor suppressor genes and oncogenes have been implicated in a variety of human cancers including those of the breast, ovary, kidney, and eye. We have recently completed pilot studies in which we examined tumor-bearing and nontumor-bearing individuals for obvious genetic markers. Specifically, we performed random amplified polymorphic DNA (RAPD) and double-stringency polymerase chain reaction (DS PCR–laboratory techniques that facilitate detection of DNA-based diseases) analysis (described in Geter et al. 1998). Tumor-bearing gizzard shad were indistinguishable from nontumor-bearing gizzard shad by genetic marker analysis performed in our studies.

Cancer in fishes has been previously reported at various locations in North America, but never in a national park

Field studies, in which fish were sampled from various locations at different times of the year supported the hypothesis that tumor-bearing and nontumor-bearing shad collected from Lake of the Arbuckles represent a single genetically homogeneous population (Jacobs and Ostrander 1995).

Tumors in other fish?

The primary focus of our studies for the last six years has been the gizzard shad and, as such, our sampling methods are optimized to target this species. Nonetheless, we often capture nontarget species in our nets. These fish are routinely examined grossly for tumors and on occasion complete necropsy is performed. The most common non-shad species caught is the catfish, and to date no tumors have been seen. Over the years we have also caught about 30 bass, including white, smallmouth, and largemouth. Two individuals have presented tumors and one of these has been examined in some detail (Hawkins et al. 1996). A white bass exhibited a tumor that was a solitary soft round mass that bulged from the anal fin. The lesion was suggestive of a poorly differentiated hemangiopericytoma (a tumor that likely arose from cells surrounding a blood vessel), though it might have derived from a nerve sheath, pigment cells, fibroblasts, or smooth muscle. Hemangiopericytoma is a relatively rare lesion in wild fish. Its discovery in a white bass from the same location in which resident gizzard shad exhibit a high frequency of similar lesions arising from cells around nerves instead of blood vessels is of concern. Further surveys and studies of non-shad species are needed.

Unlike hemangiopericytoma, pigmented subcutaneous spindle cell neoplasm is a tumor that arises from cells surrounding nerves. Tumors of this type were first observed in gizzard shad in 1991 and thought to be limited to Lake of the Arbuckles; however, a similar incidence (~20%) of this disease has now been documented in three additional lakes. Two of these lakes, Texoma and Murray, are located about 55 km (34 mi) south of Lake of the Arbuckles and share the same drainage. Sampling was conducted at multiple sites at lake Texoma (Glasses, Caney, and Lebanon) and one site at Lake Murray (see fig. 2). Both Lake of the Arbuckles and Lake Murray were stocked by the Oklahoma Department of Water Quality with gizzard shad from Lake Texoma in 1980 (J.Pigg, personal communication). This suggests that antecedents of tumor-bearing shad from Lake of the Arbuckles and Lake Murray were introduced from the same source at the same time; that is, they may have a common ancestor that carried this deleterious trait. A third lake, Fort Supply, is found in the

See "Shad" on page 36

"Shad" continued from page 35

western panhandle region and is outside this drainage. In all cases the incidence of tumors remains roughly 20%.

For the study, researchers collected juvenile and adult shad from Lake of the Arbuckles with a beach seine.

Future direction

To date we have not been able to determine the cause or source of the tumors appearing in gizzard shad in four Oklahoma lakes. Moreover, neither the geographical extent of the outbreak nor when it began are known. Finally, the exact cell(s) of origin for the tumors remains to be determined. Our current studies are focused on answering these questions. PS

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eggs being laid in vireo nests (2.0 eggs per nest in 1998) is an indication that cowbird egg production can outpace the breeding capacity of preferred hosts. The high rate of parasitism on Bell's vireo is alarming and could lead to an unstable population that is susceptible to extirpation. These numbers indicate that the continued presence of Bell's vireo at Rattlesnake Springs is at risk, requiring long-term monitoring and management action.

To reduce the impacts of cowbirds, the park has removed horses from Rattlesnake Springs, buried powerlines that were commonly used as perches by cowbirds, and removed or addled cowbird eggs from Bell's vireo nests. Future management actions may include increasing the riparian habitat and trapping cowbirds.

Rocky Mountains

Whirling disease found in Yellowstone

During the 1998 field season, staff from Yellowstone's Aquatic Resources Center confirmed the presence of whirling disease in the park. In recent years, the disease, caused by a parasite that attacks the cartilage of young fish, has been found in streams around the park, but previous sampling efforts had not indicated its presence within Yellowstone. In three separate tests, native Yellowstone cutthroat trout taken from Yellowstone Lake near the mouth of Clear Creek, a major spawning tributary, tested positive for whirling disease. Fish affected by the disease are unable to feed normally, which often results in their being more subject to predation, starvation, and premature death. Biologists will test additional fish from in and around the lake during the summer of 1999 to learn more about the extent of the disease.

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NAS begins review of natural regulation in Yellowstone

In 1998, Congress requested that the National Academy of Sciences (NAS) initiate a comprehensive and objective review of ungulate management in Yellowstone. The group's first visit to Yellowstone occurred in mid-January, during which they heard from a variety of speakers. Twelve scientists have been appointed to the task, which is expected to take approximately two years and has been allocated funds of $500,000. PS

Ecosystem-based assessment of biodiversity associated with eastern hemlock forests

By Carolyn G. Mahan

The eastern hemlock *(Tsuga canadensis)* is a shade-tolerant, late-successional conifer that provides a unique cover type in the eastern forest (Rogers 1978). Eastern hemlock stands are highly valued at Delaware Water Gap National Recreation Area (New Jersey and Pennsylvania–fig. 1) and Shenandoah National Park (Virginia) because of their aesthetic, recreational, and ecological qualities. Personnel and cooperators from Delaware Water Gap and Shenandoah have conducted ecological studies in hemlock stands and identified numerous species of plants and wildlife, some of which are sensitive species, within this unique forest habitat (Sciascia and Pehek 1995, Battles et al. 1996). For example, blackburnian warblers *(Dendroica fusca)* and water shrews *(Sorex palustris)* are closely associated with hemlock stands (Benzinger 1994, Sciascia and Pehek 1995). At Shenandoah National Park, some populations of the federally endangered Shenandoah salamander *(Plethodon shenandoah)* occur in dense hemlock stands (Mitchell 1991, Watson et al. 1994). Moreover, plant species such as painted trillium *(Trillium undulatum)* grow primarily under the canopy of hemlock stands (Radford et al. 1968).

The aesthetic, recreational, and ecological values of hemlock stands at Delaware Water Gap and Shenandoah are threatened by the hemlock woolly adelgid (*Adelges tsuga* Annands; HWA), an exotic insect pest that attacks and can kill eastern hemlock trees (McClure 1991–fig. 2, page 38). The hemlock woolly adelgid was first detected in Shenandoah in the winter of 1988 and now infests all eastern hemlock stands at that park causing significant mortality of hemlock trees (Watson et al. 1994). Resource managers at Delaware Water Gap learned in 1989 that hemlock stands were infested with the insect (Evans 1995).

The biodiversity associated with hemlock stands could be at risk if the current trend of HWA infestation and resulting mortality continues. The National Park Service endeavors to protect and maintain the natural heritage of its lands, particularly under the threat of an invasive exotic species such as the adelgid. Baseline information on the biotic components of hemlock ecosystems is fundamental to the protection and restoration of biodiversity and to the maintenance of ecosystem dynamics in hemlock stands at both Delaware Water Gap and Shenandoah.

Figure 1. Eastern hemlock (Tsuga canadensis) *ravine at Hornbeck Hollow, Delaware Water Gap National Recreation Area, Pennsylvania.*

The Pennsylvania State University (Penn State) and the Biological Resources Division (BRD) of the U.S. Geological Survey in cooperation with the National Park Service have conducted research to assess the biodiversity associated with hemlock and complementary paired hardwood ecosystems at the two parks (Ross et al. 1996, Yahner et al. 1996). The goals of this project were to: (1) assemble and synthesize existing information on terrestrial floral and faunal diversity at both parks; (2) develop and establish study site design for forest stands at both parks; (3) develop and standardize specified field protocols and procedures for a biodiversity inventory in hemlock and complementary hardwood ecosystems at both parks; (4) conduct aquatic biodiversity sampling in hemlock and complementary paired hardwood ecosystems at Delaware Water Gap; and (5) conduct terrestrial biodiversity sampling in a hemlock and a complementary hardwood stand at Shenandoah National Park. Aquatic research, similar to that being conducted at Delaware Water Gap, is not being conducted at Shenandoah primarily because hemlock stands at Shenandoah tend to be small and exist as very narrow strips along stream corridors. The effects of hemlock on aquatic biodiversity, therefore, may be difficult to ascertain because the non-hemlock components of the forest contribute a much larger proportion of the leaf litter inputs entering the stream.

Biodiversity database

To meet the first objective, we compiled information from existing reports, publications, museums, and databases (including NP Flora/Fauna) on terrestrial floral and faunal biodiversity found in and around the two parks (Mahan 1997a, 1997b). Biodiversity information was integrated with existing data in a newly created computerized database using Microsoft Access (termed the Biodiversity Database). Biodiversity information was collected for amphibians, reptiles, birds, mammals, vascular and nonvascular plants, and invertebrates. The database significantly enhances the information available on terrestrial biodiversity in and around the two parks. Furthermore, NP Flora/Fauna contains little to no information on invertebrates present in either park. The Biodiversity Database, however, contains over 8,000 and 1,500 species of invertebrates that potentially could be located at Delaware Water

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Gap and Shenandoah, respectively. The Biodiversity Database was installed at both parks in 1997.

Selection of forest stands

To meet the second objective, BRD researchers developed a landscape analysis methodology to select forest stands for conducting biodiversity inventories (Smith et al. 1996). Stand boundaries at both parks were defined using forest cover-type maps provided by resource managers at each park (Myers and Irish 1981, Teeter 1988). Geographic Information System (GIS) methods were used to tabulate landscape attributes of hemlock stands. Hemlock stands were clustered into three topographic types based on their landscape attributes generated from a 1:24,000 digital elevation model (USGS topography) (Smith et al. 1996). Landscape attributes used for classifying and clustering hemlock stands included: elevation, percent slope, aspect, and terrain shape (Smith et al. 1996). Hemlock stands in each topographic type were then paired with hardwood forest stands using multivariate distance based on similar landscape attributes. Potential study stands were visited at Delaware Water Gap and Shenandoah to check the appropriateness of using the proposed methodology to stratify stands based on topographic type. Fourteen and seven pairs of hemlock and hardwood forest stands were selected as potential study sites at Delaware Water Gap and Shenandoah, respectively (Mahan 1997c, 1997d).

Biodiversity inventories: protocol manual

For the third objective, a manual that details standardized field protocols for inventorying terrestrial and aquatic flora and fauna was prepared (Mahan et al. 1998). Protocols for terrestrial floral and faunal inventories were standardized and developed by researchers at Penn State. Protocols for aquatic sampling were standardized and developed by researchers from the USGS Biological Resources Division (Ross et al. 1996). The protocol manual was reviewed by resource managers at Delaware Water Gap and Shenandoah and researchers associated with the Smithsonian Institution's Monitoring and Assessment of Biodiversity Program (see Dallmeier 1992).

Aquatic biodiversity inventories at Delaware Water Gap

To obtain the necessary information on the aquatic components of biodiversity (objective 4), macroinvertebrate and fish assemblages were sampled in stream reaches within 14 hemlock and paired hardwood stands at Delaware Water Gap during 1997. Aquatic macroinvertebrates and fish were sampled were sampled during April and July, respectively. Sampling events were timed to maximize resident species diversity (Ross et al. 1996). Length of stream reaches sampled were proportional to stream width and reflected existing landscape variation (Ross et al 1996). Macroinvertebrate and fish samples were collected from a variety of microhabitats within stream reaches in each stand. Streams draining hemlock forests at Delaware Water Gap contained approximately 37% more taxa of aquatic invertebrates than streams draining hardwood stands (Snyder et al. 1999). In addition, streams draining hemlock forests supported more predatory invertebrates than stream draining hardwood stands. Finally, brook trout *(Salvelinus fontinalis)* were more likely to occur in streams draining hemlock forests (Snyder et al. 1999).

Terrestrial biodiversity inventories at Shenandoah

To obtain the necessary information on terrestrial flora and fauna (objective 5), a biodiversity profile inventory (plot-based sampling) using numerous sampling protocols was conducted in conjunction with more extensive sampling across a larger area (stand-based sampling). The terrestrial biodiversity profile inventory was conducted during 1997 at one hemlock stand (Limberlost) and a complementary paired hardwood stand (Matthew's Arm) in Shenandoah National Park. The biodiversity profile inventory included intensive sampling for terrestrial plants, vertebrates, and invertebrates from the forest soil to the forest canopy within a 20 m x 20 m plot. Although preliminary results suggest that hardwood forests are more biologically diverse than hemlock forests at Shenandoah, hemlock forests do seem to have unique species composition and structure. For example, many families of terrestrial invertebrates were only found in the hemlock stand (Sullivan et al. 1998). Several families of flies that depend on decaying organic matter and fungi were more abundant in the hemlock forest. Furthermore, orb-weaving spiders, a group of spiders that requires open habitat structure, were more abundant in the hemlock forest. Individuals of the bark lice family Peripsocidae, and the millipede family Parajulidae, also were more abundant in the hemlock than the hardwood forest at Shenandoah. Red-backed salamanders *(Plethodon cinereus),* which feed on large detritivorous invertrebrates, such as millepedes, were significantly more abundant in the hemlock forest. Finally, southern red-backed voles *(Clethrionomys gapperi),* a fungivorous small mammal species, appear to be more abundant in the hemlock forest at Shenandoah.

Figure 2 (above). Eastern hemlocks at Thornton Gap, Shenandoah National Park, have died as a result of hemlock woolly adelgid infestation. Note the gap created in the forest canopy by the dead hemlock.

Hemlock stands at Shenandoah National Park and Delaware Water Gap National Recreation Area support unique assemblages of terrestrial and aquatic species that contribute significantly to the biodiversity of the mid-Atlantic's predominantly hardwood landscape. Loss of hemlock ecosystems due to infestation by the hemlock woolly adelgid may result in significant losses of biodiversity especially in unique invertebrate assemblages. These baseline data on the biotic components of hemlock ecosystems is fundamental to the protection, maintenance, and restoration of hemlock ecosystems threatened by the hemlock woolly adelgid. PS

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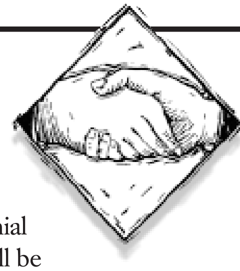
indicator species are not the most reliable indicator of what is going on in the ecosystem.

I just spent four days on Hazel Creek in the park with the fisheries crew, representatives of the North Carolina fisheries program, and the North Carolina local chapter of Trout Unlimited. We collected and transported 175 native brook trout to a stream that had died in the 1920s because of silt loading from logging before the park was established. This was the third year I participated. In past years, we have censused streams, collected data, and looked for restoration sites for brook trout. I cannot describe how moved I was to walk along an old railroad bed with park neighbors and allies carrying back into the wilderness descendants of those living creatures that were destroyed so many years ago. To have come to a point where we could overcome ignorance and take yet another step towards full restoration of this significant park, brought this superintendent to tears. I was not alone in that feeling. The Trout Unlimited representatives who had paid for the project shared it, as did the North Carolina agency people who now count park resources as part of theirs.

I have less trouble imagining the National Park Service having the ability to inventory *what* exists in parks than imagining us keeping the momentum going to continue monitoring for all time. In the field last week, I felt perhaps it's being able to communicate those special moments that will enable us to keep people's interest alive in spending the money for monitoring. Let's be sure to share with the public what monitoring really means for our resources.

Finally, let me finish by telling you that the Smokies is now in the initial stages of attempting a feat that has not been accomplished in the world: a complete inventory of all our species including bacteria. One of the main reasons for doing such a project is to heighten public awareness of just how important such a project is in order to provide stewardship for these resources in perpetuity. When you read about the Discover Life in America/All Taxa Biodiversity Inventory in the Smokies, please remember that we are not only trying to share with the world the significance of this park, but also the significance of the treasure house of resources preserved in national parks. Getting people excited about what we find in the Smokies may help all land managers with the challenge of articulating why we need to know and what it means once we do know. PS

Meetings of Interest



March 22-26

The 10th George Wright Society Conference on Research and Resource Management in Parks and on Public Lands is quickly approaching. This biennial gathering of researchers and resource managers will be held in Asheville, North Carolina, near Blue Ridge Parkway and Great Smoky Mountains National Park. Entitled *On the Frontiers of Conservation: Discovery, Reappraisal, and Innovation,* the conference is organized around concurrent sessions with tracks on management, analysis and synthesis, and Appalachian issues. Details of the conference, its program, and session abstracts are now posted online at *www.portup.com/~gws/gws99.html,* or contact the Society at *gws@mail.portup.com* or 906-487-9722.

May 23-27

To convene in Missoula, Montana, the conference *Wilderness Science in a Time of Change* is fast upon us. Since the first National Wilderness Research Conference in 1985, interest in wilderness has increased, international and societal definitions of wilderness have evolved, and wilderness science has improved. The science gathering will feature research results and knowledge synthesis and its management implications. Three symposia are planned: (1) *Science for understanding wilderness in the context of larger systems;* (2) *Wilderness for science: A place for inquiry;* and (3) *Science for wilderness: Improving management.* Plenary sessions will explore the interface of science and wilderness. Details of the conference including the agenda are posted on the Web at *www.umt.edu/wildscience/default2.htm.* For program information contact David Cole, *Cole_David/rmrs_missoula@fs.fed.us;* registration information is available from Clare Kelly, *ckelly@selway.umt.edu* or call 888-254-2544.

September 23-25

The Society for Ecological Restoration is planning the international conference *Reweaving the World: Restoration, Community, Culture,* to be held at the Presidio in San Francisco, California. Three symposia are planned: *Restoration of Public Lands; Watershed Politics and Management; and Community, Connection, and Stewardship.* The conference will explore ecological restoration from numerous perspectives and scales: large, small, and personal. Workshops, field trips, and presentations will explore current practice and science as it relates to the growing field of ecological restoration. The Society is accepting abstracts and posters until March 15 on the following topics: ethics, research, mining reclamation, wildlife, wetlands, forests, marine, grasslands, fire ecology and management, monitoring, resource education, among others. Conference information can be found at *www.sercal.org/ser99.htm,* or contact the program chair at *amshoff@earthlink.net;* 805-634-9228.

October 11-13

The Fifth Biennial Scientific Conference on the Greater Yellowstone Ecosystem is now in the works and accepting proposals for papers and panel sessions. Entitled *Exotic Organisms in Greater Yellowstone: Native Biodiversity Under Siege,* the conference will explore the conservation of wild biological resources, which is increasingly a matter of protecting native plant and animal assemblages from the threat of nonnative invasions. Topics for discussion include defining "nonnative," the use of biocontrols, ethical considerations for nonnatives, related socioeconomic issues, research and management of numerous nonnative species, and the effects of nonnatives on resources and the human experience in greater Yellowstone. One-page, double-spaced abstracts should be transmitted electronically to *joy_perius@nps.gov* by March 1. The conference will be held at the Mammoth Hot Springs Hotel; registration information is available by calling 307-344-2209.

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