

PARKSCIENCE

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PLIGHT OF THE DEVILS HOLE PUFFISH
AT DEATH VALLEY

RARE SEABIRD RECOVERY
AT CHANNEL ISLANDS

REDUCING ANIMAL-VEHICLE CRASHES
IN A CANADIAN NATIONAL PARK

REDISCOVERY OF
A LONG-LOST FOSSIL DEPOSIT
AT VALLEY FORGE

NEW INFORMATION FOR
COUGAR MANAGEMENT

DISCERNING FIRE HISTORY
AT OZARK

BAT MONITORING
AT LAVA BEDS

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UNITED STATES DEPARTMENT OF THE INTERIOR



NATIONAL PARK SERVICE

CELEBRATING THE VICTORIES

I was a junior in high school on a three-day ocean adventure with my dad and his friends in 1974 as we sailed among several islands of Channel Islands National Monument. Travel by boat was a very exciting prospect, and in the hours and days it took to navigate from nearby Los Angeles to Santa Barbara, Anacapa, and Santa Cruz Islands a change had begun to take place in me. Just 80 miles from home I was really a world away, enjoying a fresh breeze, warm sun, and good companionship. The experience was deeply satisfying and would help to form a lasting desire to incorporate nature, challenge, curiosity, and stewardship into my lifestyle and career. Though the work of the National Park Service may not have been much on my mind as we sailed, I took in the beautifully rugged scenery of Anacapa Island (photo) and wondered about its geology, the force of the surf pounding its rocky shores, and the animals and plants that must live there. At the time, I had no idea that the island had already lost some of its natural character and diversity on account of introductions of nonnative plant and animal species. From my perspective, it seemed a mysterious place.

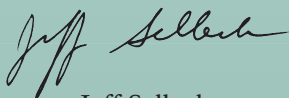


NPS

More than 30 years since my introduction to what is now Channel Islands National Park, nonnative species are still a tremendous conservation problem throughout the park. Despite this reality, we are able to report what is beginning to look like a solid victory on Anacapa: the recovery of a tiny seabird called Xantus's murrelet. A true highlight for this issue is the summary of monitoring results on page 9 that indicate a significant increase in nesting success and effort in the population of this rare and secretive species. This exciting turnaround comes almost certainly as a result of the recent, multiyear effort to eradicate nonnative black rats from the island. Though island ecosystems remain as vulnerable as ever to nonnative plant and animal invasions, I think it's important to recognize the undaunted efforts that led to this encouraging progress toward reestablishing Anacapa as a place that is more distinct—at least in terms of murrelets—than it was in 1974 or just a few years ago. I look forward to my next visit to the Channel Islands with the knowledge that a special black-and-white seabird is on its way to recovery. Our hats go off to the park staff and their hardworking partners and supporters for this terrific news.

Also in this issue, we mark a very different milestone in natural resource management with the announcement on page 12 of the publication of *Cougar Management Guidelines*. One of the first articles I edited for *Park Science* 11 years ago detailed a workshop to improve the understanding and management of cougar-human encounters, which were increasing in parks throughout the West. While that effort led to basic management guidelines applicable to several western national parks, the new guidelines—published independently with involvement of numerous collaborators, including the National Park Service—synthesize decades of research on cougar biology and conservation and are relevant wherever humans and cougars might meet. This authoritative resource should be very useful to biologists, managers, and others involved in making decisions regarding this complex human safety and wildlife preservation issue.

To my way of thinking, these are conservation victories because they advance resource management through science and deliver meaningful results on the ground. Moreover, these successes could not have been accomplished without persistence, professionalism, and collaboration—qualities that are extremely important for effective resource management. Given the continual challenges we face in our daily efforts to understand and conserve park resources, let's not forget to celebrate the victories as they occur.



Jeff Selleck

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NPS (2)

GREG BELLAND

NPS/JOHN WULLSCHLEGER



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ON THE COVER

Located in Nevada near Death Valley National Park, Devils Hole constitutes the entire aquatic habitat of what may be the world's most isolated fish species: the Devils Hole pupfish. The surface waters are an indication of a vast aquifer that underlies a large part of Nevada. Scientists have recently redoubled their efforts to understand a variety of factors, including dropping water level, water chemistry, and physical processes, that may relate to a recent decline in the population of this unlikely desert fish species. For more of the story, turn to page 26.

COVER PHOTO—NPS/JOHN WULLSCHLEGER

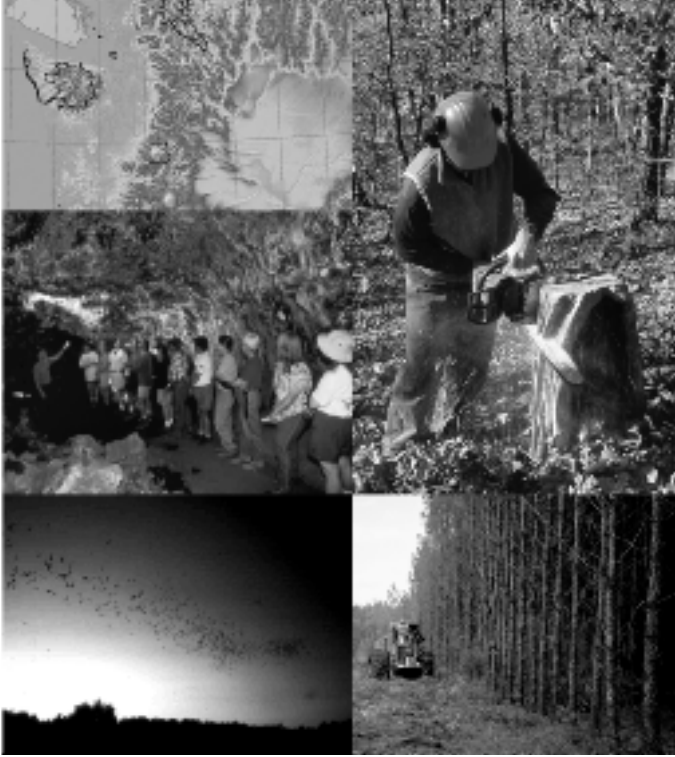
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Corrections

We have three errors to correct from the last two issues of *Park Science*:

Whooh! do we really mean?

First, on the cover of volume 23(1) we inadvertently mixed up our owl species in the blurb that read “Implications of spotted owl range expansion at Redwood.” Author Howard Sakai quickly pointed out the mistake, which we regret. The *barred owl* is the species whose range is expanding into Redwood National and State Parks, potentially affecting spotted owls (a threatened species) and concerning managers.

Mistaken identity

Another error involved the cover of that issue, in particular, the photograph and our description of its location in the caption “On the Cover” on page 3. We identified the beautiful meadow and mountain scene as belonging to Sequoia National Park, but reader Larry Norris placed it correctly in neighboring Kings Canyon National Park. Specifically, the photo depicts Big Wet Meadow along the Roaring River. He says, “The granite boulder on the left of the photo is a favorite lunch spot of mine with a fine view up to the Whaleback and points beyond.”

What is more important to clarify than the mistaken location is that the body of water in the image is not a lake, as we say in the caption. It is a flooded meadow. This error is relevant in the discussion of Harold Werner’s article on page 19 of volume 23(1), which describes a method of checking the accuracy of wetlands classification and delineation in maps of the National Wetlands Inventory (NWI), since NWI errors occur as a consequence of misinterpreting aerial photographs. As he puts it, “There are no NWI lakes in that meadow.” Larry Norris confirms from first-hand experience that the drainage constricts at the end of the meadow, temporarily collecting water during periods of high snow melt. Norris has “seen and measured the back-up in 1981 and subsequent years on hot summer days when snow-melt water floods the grass and flowers in the meadow late in the day.” He also witnessed a rise of 3–4 inches in water level following a thunderstorm there in July 1997, and says, “That was cool.”

Incorrect citations

Finally, references cited for five publications in the article by Kathryn McEachern on the “Ecological effects of animal introductions at Channel Islands National Park” (*Park Science* 22[2]:46–52) were incorrect. Four citations (i.e., Carroll et al. 2003, page 18; Loehner 2003, page 82; McEachern et al. 2003a, page 153; and Whitworth et al. 2003, page 133) represent abstracts of presentations made at the Sixth California Islands Symposium, 1–3 December 2003, as published in the abstract program for the symposium, not in the peer-reviewed proceedings. The fifth, by Stratton, was likewise a presentation at the symposium and also a published paper in the 2005 proceedings. The correct citations for the proceedings and abstract program, respectively, are:

Garcelon, D. K., and C. A. Schwemm, editors. 2005. Proceedings of the Sixth California Islands Symposium, Ventura, California, December 1–3, 2003. National Park Service Technical Publication CHIS-05-01. Institute for Wildlife Studies, Arcata, California.

National Park Service. 2003. Abstract program for the Sixth California Islands Symposium, Ventura, California, December 1–3, 2003. Channel Islands National Park, Ventura, California.



Letter

Understanding the role of air pollution in species invasions

The Fall 2004 issue of *Park Science* (volume 22, number 2) provided an excellent overview of the invasive species crisis now facing the National Park Service (NPS). The cover article and the accompanying features and short articles combined to tell a compelling story about this “biological wildfire” and its implications for native biodiversity and natural ecosystems. As many of the authors pointed out, biological invasions constitute one of the most significant threats to terrestrial, aquatic, and marine systems, with the potential for changing the very character of the parks we treasure. The articles discussed the many factors that encourage invasives, including habitat disturbance, breakdown of natural barriers, and intentional or accidental introductions. As biologists with the NPS Air Resources Division, we would also like to highlight the role of air pollution in biological invasions, particularly plant invasions.

Evidence is mounting that air pollution, in the form of atmospheric nitrogen deposition, is encouraging the proliferation of alien annual plants, and possibly promoting the invasion of new species in certain regions. Nitrogen compounds, emitted from automobiles, power plants, and agricultural activities, can be transported by air currents and deposited far from their sources. Current rates of nitrogen deposition across many areas of the United States are from one to two orders of magnitude higher than in preindustrial times, and in some areas nitrogen deposition is increasing. Nitrogen deposition has been implicated in the decline of coastal sage scrub vegetation of southern California and its subsequent replacement by Mediterranean annual grasses (Allen et al. 1998). Increased nitrogen has been shown to increase the dominance of alien annual plants in the Mojave Desert (Brooks 2003) and decrease species richness in alpine tundra in the Rocky Mountains (Bowman 2000). An analysis of more than 900 plant species responses from 34 fertilization experiments across nine terrestrial ecosystems in North America showed that nitrogen additions reduced species diversity, with rare species often being lost. The researchers concluded that as nitrogen availability increases, management that focuses on locally susceptible functional groups and generally susceptible rare species will be essential to maintain biodiversity (Suding et al. 2005).

These results indicate that air pollution, in the form of nitrogen deposition, may have a profound effect on native vegetation communities and their responses to invasions and future restoration efforts. We would like to suggest, therefore, that nitrogen deposition be considered when developing strategies for monitoring and restoring sites impacted by invasive plants. In the *Park Science* article

“Assessing the invasive plant issue,” Benjamin and Hiebert outlined the requirements of an effective weed inventory, mapping, and monitoring program, and proposed a strategy for prioritizing disturbed sites for restoration. We recommend that this strategy also include an assessment of long-term, cumulative nitrogen deposition at impacted sites, as well as research on the effects of nitrogen on plant communities.

The Air Resources Division of the National Park Service is funding projects at Joshua Tree, Rocky Mountain, and Big Bend National Parks, and other areas to evaluate nitrogen impacts on natural vegetation communities, and is developing strategies to estimate “critical loads” for atmospheric deposition (Porter et al. 2005), that is, “how much is too much.” Critical loads for site-specific changes in species composition may eventually help us assess an area’s vulnerability to invasion or its potential for restoration.

Addressing biological invasions must be done on many fronts. In addition to working with partners on our park borders to control local plant invasions, we must continue to work with state and local air regulatory agencies, and industries, to reduce nitrogen deposition to parks. As Lloyd Loope pointed out in the cover article, “Major breakthroughs in science, policy, and management will likely be needed to address the complex and important issue of biological invasions if substantial impairment of the parks is to be averted.” Some of the complexities of the challenge, including the role of air pollution, are just being recognized. Consideration of all factors contributing to invasions will be necessary if the National Park Service is to meet this challenge and keep our parks “unimpaired for the enjoyment of future generations.”

—Ellen Porter (ellen_porter@nps.gov) and Tamara Blett (tamara_blett@nps.gov), NPS Air Resources Division

References

- Allen E. B., P. E. Padgett, A. Bytnerowicz, and R. Minnich. 1998. Nitrogen deposition effects on coastal sage vegetation of southern California. General Technical Report PSW-GTR-166. USDA Forest Service, Riverside, California.
- Brooks, M. L. 2003. Effects of increased soil nitrogen on the dominance of alien annual plants in the Mojave Desert. *Journal of Applied Ecology* 40:344–353.
- Bowman, W. 2000. Biotic controls over ecosystem response to environmental change in alpine tundra of the Rocky Mountains. *Ambio* 29:396–400.
- Suding K. N., S. L. Collins, L. Gough, C. Clark, E. E. Cleland, K. L. Gross, D. G. Milchunas, and S. Pennings. 2005. Functional- and abundance-based mechanisms explain diversity loss due to N fertilization. *Proceedings of the National Academy of Science* 102:4387–4392.
- Porter E., T. Blett, D. U. Potter, and C. Huber. 2005. Protecting resources on federal lands: implications of critical loads for atmospheric deposition of nitrogen and sulfur. *BioScience* 55:603–612.

Dr. Herbert C. Frost named deputy associate director

Herbert C. (Bert) Frost has been selected to fill the deputy associate director position for Natural Resource Stewardship and Science, replacing Abby Miller. In his new position he will continue the work already in progress for the Natural Resource Challenge. Beyond that, he says, "I think we need to evaluate how our programs are currently working. We have a lot of great things going but I think we can refine some aspects and do even more with the resources we have been given. I want the Washington Office [WASO] to be receptive to the needs of the parks and I want to take as much work off the parks and regions as possible. Finally, I want people to know that we in WASO are there to help them and not to hesitate to call. We can't solve all problems, but we sure can help with some."

Frost holds a PhD in wildlife ecology from the University of Maine and has research experience with black bears, white-tailed deer, fishers, and martens. He has served as the senior natural resource manager for Eisenhower National Historic Site (Pennsylvania), and Gettysburg National Military Park (Pennsylvania), where he provided leadership for the science, planning, compliance, and implementation of the white-tailed deer management plan. He has also served as acting superintendent of Weir Farm National Historic Site (Connecticut) as part of his participation in the Northeast Region's Management Development Program.

His work experience includes positions other than those in the National Park Service. He has been a special enforcement officer for the Wyoming Fish and Game Department, assistant professor and research assistant at the University of Maine, and most recently, Cooperative Ecosystem Studies Unit (CESU) leader (Great Basin CESU, University of Nevada).

Bert has been successful in fostering productive partnerships with a wide range of constituencies. He will be a strong voice for parks and a major asset for the natural resources management team in the Washington Office.



Bert Frost at the George Wright Society conference in March 2005. NPS/CHARLES D. RAFKIND



Dan Kimball, superintendent of Everglades and Dry Tortugas National Parks. COURTESY OF BILL JACKSON

Dan Kimball new superintendent of Everglades National Park

The new permanent superintendent of Everglades National Park in Homestead, Florida, is Dan B. Kimball. He has been serving as acting superintendent of the park since February 2005. As superintendent of Everglades, Kimball is responsible for managing a revered natural resource that faces significant strategic resource challenges. "I'm especially excited to move forward with my involvement in the restoration of the Everglades, the largest ecosystem restoration project in the history of the plan-

et, and honored to be part of the very talented and dedicated team that's tackling this challenging project," he said. "I am very happy to be working with our partners to preserve and restore the integrity of park resources and the greater Everglades ecosystem." Dan will also serve as superintendent of Dry Tortugas National Park, located in the Gulf of Mexico southwest of Everglades.

Kimball's professional expertise is water and natural resource management and the evaluation of complex environmental issues. He holds a bachelor's degree in earth sciences from Dennison University in Ohio and a Master of Science from the University of Arizona. He previously served as the chief of the National Park Service (NPS) Water Resources Division, a position he held since 1993. During his tenure there, Dan played a major role in successful efforts to protect parks, such as Yellowstone National Park (Wyoming, Montana, and Idaho) and Glacier National Park (Montana), from the adverse effects of resource extraction activities. Dan has also served as acting superintendent of Zion National Park (Utah) and assistant to the NPS deputy director in Washington, D.C.

A 20-year veteran of the National Park Service, Dan previously held positions with the U.S. Environmental Protection Agency, the Office of Surface Mining, and environmental consulting firms. He has received a number of awards including the Department of the Interior Superior Service Award (1989), the Stephen Tyng Mather Award for resource conservation, given by the National Parks Conservation Association (1995), and the Pacific Northwest Regional Director's Award for Professional Excellence in Natural Resources (2002). He will be a knowledgeable and capable steward of the natural resources at Everglades National Park.



George Wright Society honors natural resource experts

The 2005 awards presented by the George Wright Society (GWS) included two winners whose expertise is natural resources: Jan van Wagtendonk (photo, below), a research forester at the U.S.

Geological Survey (USGS), received the 2005 George Melendez Wright Award for Excellence for his groundbreaking research and influence on resource management in Yosemite National Park and the Sierra Nevada; and Linda Drees (photo, right), chief of the Invasive Species Branch, Biological Resource Management Division, National Park Service, won the GWS Natural Resource Management Award for her work in combating invasive exotic species in the U.S. national parks.

The awards were given at the society's biennial conference on parks, protected areas, and cultural sites last March in Philadelphia.

Dr. van Wagtendonk was nominated for the award by Robert Manning, a professor at the Rubenstein School of Environment and Natural Resources, University of Vermont, in Burlington. Manning cited the focus of van Wagtendonk's research on three issues critical to the management of parks and protected areas: prescriptions for burning in wildland ecosystems, recreational impacts in wilderness, and the application of geographic information systems (GIS) to resource management. The George Melendez Wright Award for Excellence is the society's highest-level award.

Van Wagtendonk's study of fire led to the development of burning prescriptions and techniques that are used by the National Park Service, the USDA Forest Service, and California State Parks to safely apply fire to ecosystems that are threatened by abnormal accumulations of fuel and to allow naturally caused fires to burn under prescribed conditions. His study of the ecological and social impacts of recreational use of parks led to his model to determine how many people can be engaged in recreational activities in a wilderness area without adversely affecting natural resources. His scientific application of GIS for Yosemite has served as a prototype for other parks and land management agencies.

Linda Drees was nominated by James Akerson, supervisory forest ecologist at Shenandoah National Park, for her exemplary work in planning, organizing, implementing, and controlling the 16 Exotic Plant Management



Jan van Wagtendonk (left) receives the George Melendez Wright Award for Excellence from David Parsons, George Wright Society board member and Director of the Aldo Leopold Wilderness Research Institute. NPS/CHARLES D. RAFKIND



Award-winner Linda Drees and Exotic Plant Management Team colleagues Curt Deuser (left), Terry Cacek (middle), and Steve Anderson (right) set out in Courthouse Wash at Arches National Park, Utah, to help with an invasive plant eradication project. NPS PHOTO

Teams around the country. Those teams now serve more than 208 park units using state-of-the-art techniques and best management practices to survey, control, and monitor invasive plants. In addition, for sustainability of the program, the teams provide the local parks with control information and maintain records of exotic invasions and treatment. Drees has effectively encouraged teams to form among parks and cooperating agencies so that they can accomplish more than their respective programs would allow. She has also instituted the nationwide Alien Plant Control and Monitoring database for rapid and accurate information retrieval about program activities. Linda helps others catch her passion for resource protection by her good will and effusive persistence. By providing effective organization to combat invasive exotic species, she has made an outstanding contribution to preserving and protecting the natural and cultural resources of National Park Service lands.

Awards bestowed by the George Wright Society recognize outstanding contributions to research, resource management, and public education in and about parks and other protected areas. Other 2005 winners were John Hope Franklin, who shared the Award for Excellence with Jan van Wagtendonk. Franklin was recognized for his long and distinguished career as a historian of slavery. The GWS Cultural Resource Management Award went to Nora Mitchell for her many innovations in cultural landscape management and heritage preservation, and the GWS Communication Award was given to David Andrews, editor and designer of *Common Ground*, for his leadership of the National Park Service magazine of archaeology, ethnography, and other cultural resources.

HIGHLIGHTS

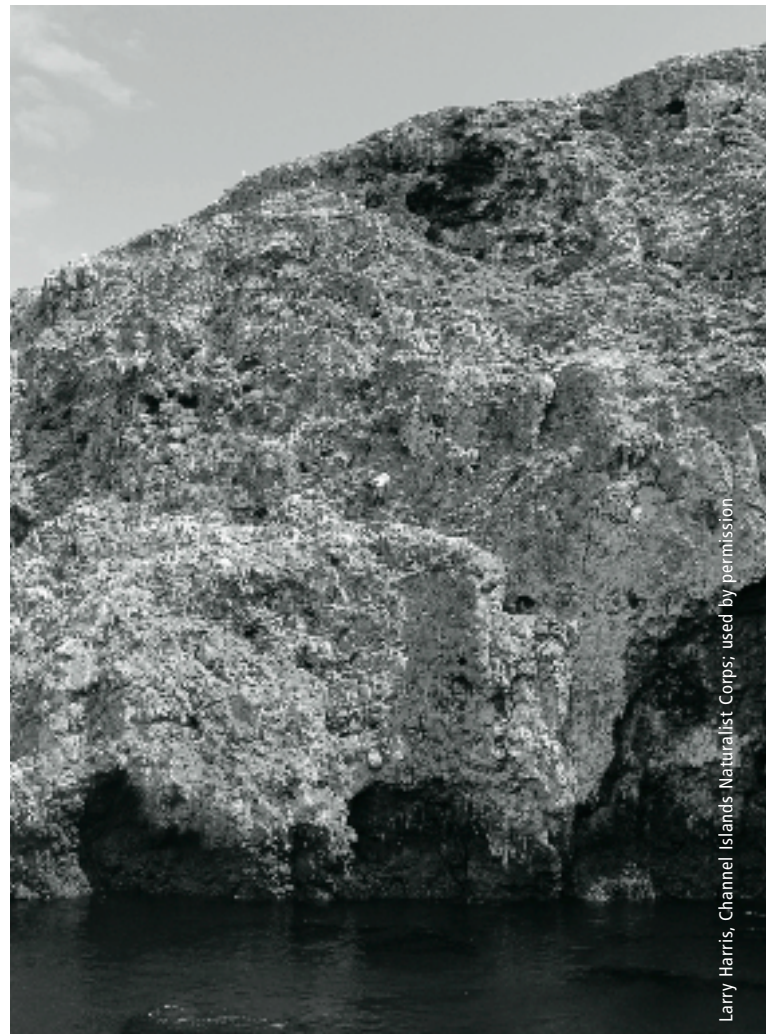
Recovering Xantus's murrelets on Anacapa Island

Xantus's murrelet (*Synthliboramphus hypoleucus*) is one of the rarest and most intriguing of the many seabirds inhabiting Channel Islands National Park (see photo). These small, inconspicuous black-and-white birds, subtropical relatives of the more familiar puffins and murres, inhabit 12 islands off the coast of southern and Baja California. Perhaps half of the world's population of this species (10,000–15,000 birds) resides in the national park on Santa Barbara, San Miguel, Santa Cruz, and Anacapa Islands.

Unfortunately, nonnative predators have been introduced to most known Xantus's murrelet breeding islands, and predator eradication programs have become a necessary tool toward ensuring the survival of this sensitive species. Nonnative black rats (*Rattus rattus*) have severely impacted murrelets on Anacapa Island over the last century, but a small population of the birds has persisted in largely inaccessible habitats around the island. The continued survival and recovery of this remnant colony led to the Anacapa Island Restoration Program. Sponsored by the American Trader Trustee Council, this ambitious project is designed to restore the natural balance of the island ecosystem by eradicating the predatory black rat. The project was planned and carried out by Island Conservation, a nonprofit conservation organization, and the National Park Service.

Rats were eliminated from Anacapa Island in two phases: (1) East Anacapa in December 2001, and (2) Middle and West Anacapa in November 2002. Because Xantus's murrelet was identified as the species most likely to benefit from the removal of rats, the California Institute of Environmental Studies (CIES), Humboldt State University, and Channel Islands National Marine Sanctuary began murrelet monitoring in 2000 to measure nesting effort and breeding success before and after rat eradication.

The murrelets' secretive habits and hard-to-observe nesting areas (see photo, below) made these studies particularly challenging. The birds visit the colony only at night and conceal their nests in small crevices in steep, rocky cliffs or sea caves. Nevertheless, the nest monitoring program has amply demonstrated the benefits of removing rats from Anacapa. The number of murrelet nests increased 81% in 2003–2005, compared to



2000–2002 (see graph). A much higher proportion of nests also successfully hatched in 2003–2005 (82%) compared to less than half (42%) from 2000–2002.

Most notably, no murrelet nests have been destroyed by rats since 2002, while nearly half (42%) of all nests found in 2000–2002 were taken by rats. Extensive nest searches have also revealed that the murrelet colony is slowly expanding into areas on Anacapa Island previously occupied by rats. Five nests were observed on the cliffs in Landing Cove in 2005, where none were known prior to 2003.

In 2004 nesting effort was relatively low due to factors unrelated to rat predation. Certainly, both natural factors (e.g., reduced prey availability) and human-related factors (e.g., oil spills) will continue to affect the rate of murrelet population recovery. However, rats were likely the primary factor that had led to low colony size and poor reproductive success at Anacapa over the last century; their eradication has greatly improved the survival prospects for this important seabird colony. Ongoing monitoring is needed to document continued recovery of Xantus’s Murrelet on Anacapa Island, and funds for this activity will be available through at least 2006.

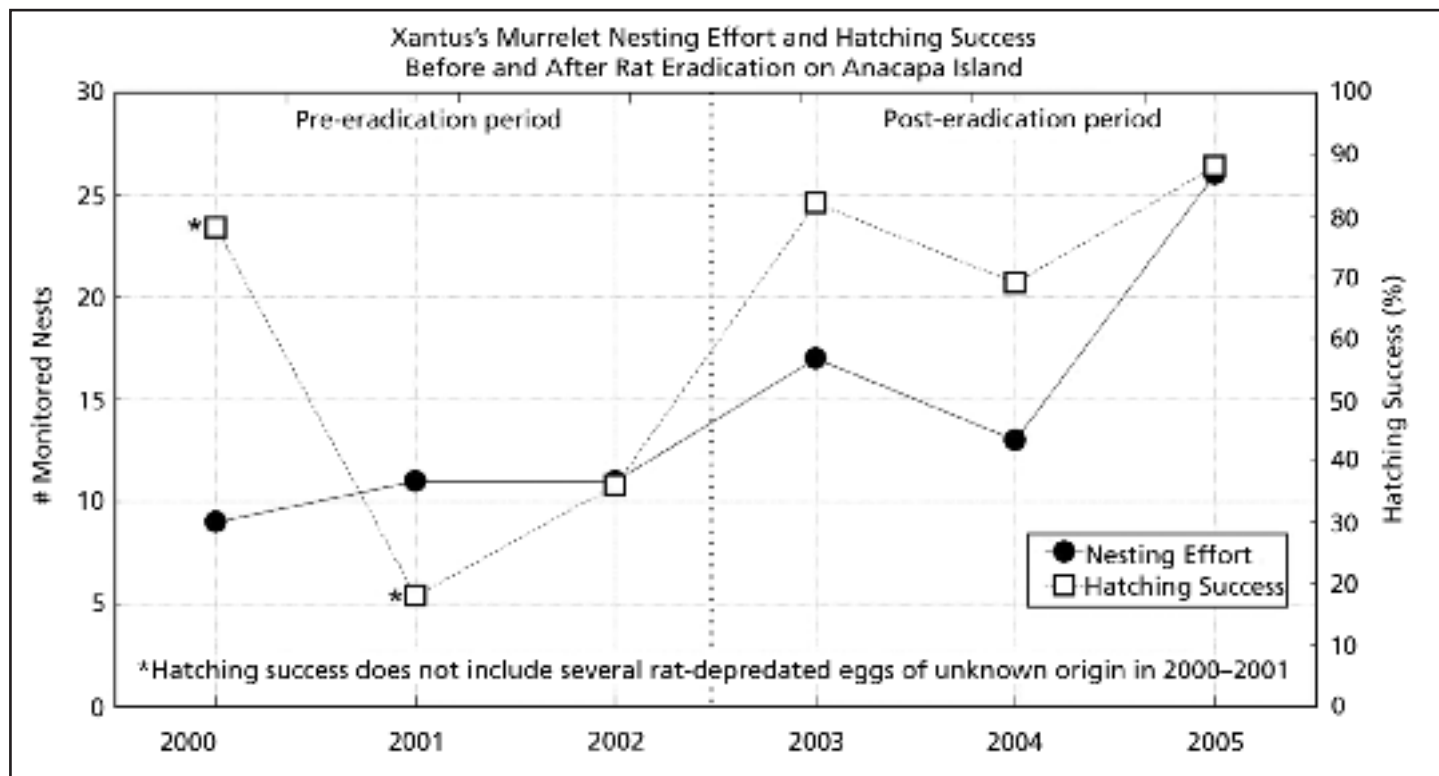
—Darrell L. Whitworth, Harry R. Carter, and Josh Koepke. Whitworth and Koepke are wildlife biologists with the California Institute of Environmental Studies, 3408 Whaler Avenue, Davis, CA 95616 USA. Carter is a wildlife biologist with Carter Biological Consulting, 1015 Hampshire Road, Victoria, BC V8S 4S8 Canada.

Monitoring enhances protection of eastern spadefoot toad at Cape Cod



The eastern spadefoot toad (*Scaphiopus h. holbrookii*, photo), one of 12 species of amphibians found at Cape Cod National Seashore, Massachusetts, is one of the rarest and least observed amphibians in the Northeast. Derived from desert ancestors,

spadefoots are “explosive” breeders. Taking advantage of infrequent windows of opportunity, they emerge at night from underground burrows to breed after very heavy rains in spring and summer, moving en masse to temporary pools. Eggs hatch within one week and, providing the pool does not dry out, larvae metamorphose in as little as two weeks. Limited by their burrowing habits to sandy and loamy regions, spadefoots occur in the Northeast along the coastal plain and river valleys. Though patchily distributed, historically they were generally abundant where present. In the last century spadefoots declined regionally because of habitat loss. They are now listed as a protected species by most northeastern states, including Massachusetts where they are “threatened.”



Mysterious heath balds investigated at Great Smoky Mountains National Park

Researchers are delving into the mysteries of the puzzling heath balds that mark the slopes of Great Smoky Mountains National Park, Tennessee and North Carolina (photo). These are treeless shrublands that occur at middle to high elevations in the park, usually on extremely steep, rocky ridges. Estimates vary, but at least several hundred of them occur in the park. Scientists have speculated for years about what created them, how old they are, and what maintains them in the face of otherwise rapid forest succession in the rest of the park.

Investigation of the heath balds was part of a larger soils mapping project funded through the Soil Resources Inventory of the Inventory and Monitoring Program. Dr. Rob Young, of the Department of Geosciences and Natural Resource Management at Western Carolina University, and his crew excavated two pits in each of 12 balds and found them to be essentially dried peat, with depths of organic layers to 39 inches (1 meter). This finding in itself is very unusual since peat lands are usually located in low, wet depressions. Wetlands in the Smokies do not seem to accumulate organic layers of peat as in the northern United States, and the balds occupy steep, rocky slopes rather than depressions.

Radiocarbon dating showed the oldest heath balds to be nearly 3,000 years old, although others appear to be much younger. The lowest layers in soil profiles of most balds are charcoal, suggesting that they developed after a fire. In at least one instance, a layer of charcoal was found part of the way down the profile, indicating that the bald existed for a long time, then burned completely, but returned as a heath bald, perhaps short-circuiting the normal succession process.

From a profile of the rich organic layers down to bedrock, researchers extracted pollen to be analyzed at the University of Tennessee, Department of Geography. The pollen may hold tantalizing information aside from answering questions about the balds, that is, *if* the pollen has been stratified in chronological order. Many species of plants have wind-blown pollen, so this profile could allow for a characterization of the Smokies forest vegetation through time, from the present to as far back as a few thousand years ago. This insight into the paleo-environment would be a significant step in understanding the natural history of the Great Smoky Mountains.

—Keith Langdon, inventory and monitoring coordinator, Great Smoky Mountains National Park, Tennessee and North Carolina;
keith_langdon@nps.gov

As recently as the year 2000, little was known about the eastern spadefoot toad at Cape Cod National Seashore except for its occurrence and distribution. Incidental observations suggested that the Province Lands, a landscape of vast sand dunes and numerous shallow ponds (ideal for spadefoots), might support significant numbers; however, a clearer picture of the toad's status only began to emerge after the establishment of the park's Inventory and Monitoring Program in 1996. Data collected in 2001 during field testing of amphibian monitoring protocols by a University of Rhode Island field crew indicated that the Province Lands area supports perhaps the largest concentration of eastern spadefoot toads in the Northeast. Unfortunately, much of this data involved animals killed on park roads on rainy nights.

Recognizing that the park supported a regionally significant population of the species, and that mortality on park roads was a potentially significant threat, park staff set out to develop a plan for temporary road closures in the Province Lands. However, one key question needed to be answered. The Province Lands encompass the Provincetown Airport and Race Point, the beach access for off-road vehicles (ORV). Both areas require access at all times. Of the two roads serving these locations, which—when closed—would prevent the greatest toad mortality?

Follow-up monitoring in 2003 found the vast majority of spadefoots on Province Lands Road, which bisects a temporary wetland they prefer. The additional study also supplied better data on the weather conditions associated with their movements. Armed with a better ecological understanding of local spadefoot life history, the park could proceed to develop an effective plan for reducing road mortalities and maintaining essential access to the airport and ORV area. Monitoring data were also combined with other information about spadefoot ecology to develop interpretive materials and a community communication strategy as part of the closure plan. Some of this interpretive material has been used by the local media and incorporated into a trolley company's tour narrative of Provincetown.

Since the park enacted the plan in 2004, overnight road closures have been implemented two to three times per year. Public reaction has been mostly positive, with few complaints. Though road kill of wildlife remains a general concern in the park, information generated by the monitoring program has enabled park staff to recognize the spadefoot problem, develop a targeted and effective response, and capitalize on an opportunity for public education at the same time.

—Robert Cook, wildlife ecologist, Cape Cod National Seashore;
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NPS



Information Crossfile

COUGAR MANAGEMENT GUIDELINES PUBLISHED

In 2001, WildFutures—a nonprofit that works to advance carnivore and ecosystem protection—received funding to organize a meeting of invited scientists and conservation experts to discuss the state of cougar (*Felis concolor*) management. During this meeting, participants committed to producing detailed management guidelines that would help state, federal, and other wildlife and land management agencies. Thirteen participants from this meeting formed the Cougar Management Guidelines Working Group. These individuals have more than 200 years of combined experience in cougar research, management, and conservation. The group compiled and reviewed all published literature on cougars, as well as many unpublished works. These individuals wrote the guidelines and sought and incorporated comments and edits from wildlife agencies in many states and provinces where cougars occur.

After three years of collaboration and painstaking review by the group and other experts throughout North America, the first edition of *Cougar Management Guidelines* is now available from Opal Creek Press at www.opalcreekpress.com/cougar.html or by calling 866-375-9015; the cost is \$21.95. The Cougar Management Guidelines Working Group considers the publication a “living document,” hence its release as a “first edition,” and plans to incorporate new data and methodologies as they become available.

The eight-chapter, 137-page book is a state-of-the-art guide for cougar management in the United States, Mexico, and Canada. The comprehensive document includes a historical perspective on cougar management and policies in North America and covers the topics of

cougar-prey relationships, cougar habitat, assessing cougar populations, policies and guidance for managing cougar depredations, recommendations for managing cougar sport hunting, strategies to manage human-cougar conflicts, and cougar research priorities. Although the primary audience of the publication is wildlife managers, many others such as field biologists, decision makers, educators, and representatives of private organizations who are interested in cougar management and conservation will also find the volume useful because it summarizes and distills decades of research into a series of succinct, rigorous guidelines. The 13 authors of *Cougar Management Guidelines* believe this document will make a substantial contribution toward conservation of this carnivore and management of the growing incidence of human-cougar conflicts. Reviewers—including Stephen Herrero, professor emeritus of environmental science at the University of Calgary, and David Mech, senior scientist with the U.S. Geological Survey—enthusiastically endorse the book’s thoroughness and relevance.

One of the book’s coauthors is Terry Hofstra, chief of Resource Management and Science at Redwood National and State Parks in Orick, California. Hofstra’s first serious involvement in cougar management issues began in 1994 when he was struck by a family’s report of an encounter with a cougar on one of the park’s most popular trails. Up to that point, observations of cougars had been infrequent with no reports of people feeling threatened. This report was different and began a series of similar incidents within a short period. Visitors described cougars as not leaving trails or moving in the vegetation near trails. They also noted cougars howling, hissing, and snarling, and a jogger communicated being stalked. Park managers closed the trail where both visitors and staff had made these observations; however, Terry recalls thinking, “Now what?” As he and other park staff at Redwood discussed their options, they realized that their knowledge and understanding of cougars was very poor. Moreover, as they made inquiries, they clearly saw that they were not alone. Park staffs throughout the West were having similar experiences and struggling with the



ILLUSTRATION, DUGALD STERMER

same questions: How should the National Park Service respond to such reports? What level of risk to humans do the reported cougar behaviors pose? Why did this activity seem to start suddenly?

To address concerns about cougar-human interactions, Redwood National and State Parks and the Cooperative Park Studies Unit of the National Biological Service (now the USGS Biological Resource Discipline) organized a workshop at the University of California, Davis, in July 1994. Participants from government, academia, and wildlife institutes distilled existing information about interpreting observable cougar behaviors: What exactly are humans likely to observe when they encounter a cougar? More importantly, how should park managers interpret those behaviors? A summary of the workshop was published as Moorhead and Hofstra (1994). A follow-up workshop in December of that year identified top-priority cougar research questions, and in spring 1995, Hofstra drafted rudimentary guidelines to help park managers understand cougar ecology and interpret and respond to cougar-human interactions. In 1998, with Natural Resource Preservation Program funding, the National Park Service and California State Parks researched cougar distribution and habitat use in relation to human activities at Redwood National and State Parks. This work was carried out in partnership with the USGS Yosemite Field Station, Humboldt State University, and the Hornocker Wildlife Institute at the University of Idaho. These efforts represent an important start in the development of science-based management of cougars in the National Park System.

Hofstra believes the new *Cougar Management Guidelines* is just what managers needed 10 years ago: "If a resource like this had been available when cougar-human encounters were on the rise in parks, I believe we would have felt a lot better. This document neither dictates policy nor prescribes management actions, but provides a baseline of scientific information with suggestions for managers to consider in light of the issues facing them at their own parks." Published in July, the book has already sold about 500 copies, 175 of which have gone to staff at mostly western units of the National Park System. Any proceeds will help fund a follow-up second edition that will incorporate new information as management actions are tried and refined in the field.

References

- Cougar Management Guidelines Working Group. 2005. Cougar management guidelines. First edition. WildFutures, Bainbridge Island, Washington.
- Moorhead, B., and T. Hofstra. 1994. Western park personnel meet on mountain lion-human encounters. *Park Science* 14(4):20-21.

UNDERSTANDING THE LIFE OF POINT LOMA

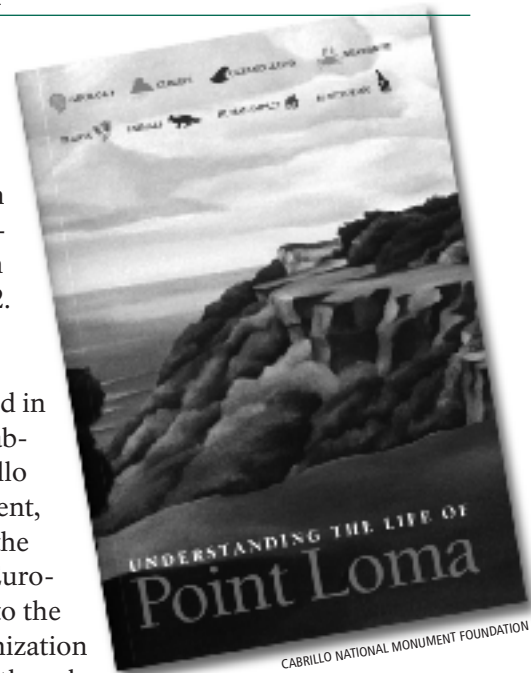
The Point Loma peninsula has 75 million years of history leading up to Juan Rodriquez Cabrillo's landing at San Diego Bay in 1542. The explorer's accomplishments were memorialized in 1913 with the establishment of Cabrillo National Monument, California. Since the time of this first European expedition to the West Coast, colonization followed by growth and

development have altered the landscape. The native coastal sage scrub, rocky coastline, tide pools, and kelp forests of the monument are remnant habitats for myriad terrestrial and marine plants and animals.

In order to educate people about Point Loma, the Cabrillo National Monument Foundation published *Understanding the Life of Point Loma*. It is the first book written specifically about the natural resources of Point Loma. The seven-chapter publication provides information about Point Loma's geologic history, climate and oceanography, nearshore environment, plant communities, animals, and history of human impacts. The final chapter, "Taking the Vital Signs: Monitoring and Management," details ongoing NPS and collaborator efforts to preserve the natural systems of the peninsula. Authors of the book include geology professors from San Diego State University, a California state government oceanographer, biologists of the U.S. Geological Survey and Scripps Institution of Oceanography, and present and past park staff.

Readers of this book will gain insights into the workings of the plant and animal communities on an interesting island-like peninsula within California's second-largest city. The 184-page book is available for \$16.95 from the Cabrillo National Monument bookstore or by calling 619-222-4747.

Additionally in fall 2005, park staff will provide an opportunity for visitors to view a portion of the monument that they do not normally get to see when they visit: the intertidal zone. A new 22-minute film about the tide pools highlights underwater creatures and microscopic



inhabitants of this biologically diverse coastal environment. The film addresses the causes of tides and intertidal zonation; it introduces viewers to the nearshore environment in the Point Loma kelp forest and the relationship between the kelp forest and the intertidal zone. The movie also discusses human impacts and NPS efforts to study, understand, protect, and educate visitors about the intertidal zone. After the movie premier, park staff plans to have it available to local schools and for sale through the Cabrillo National Monument Foundation. Local PBS and cable outlets may also provide access.

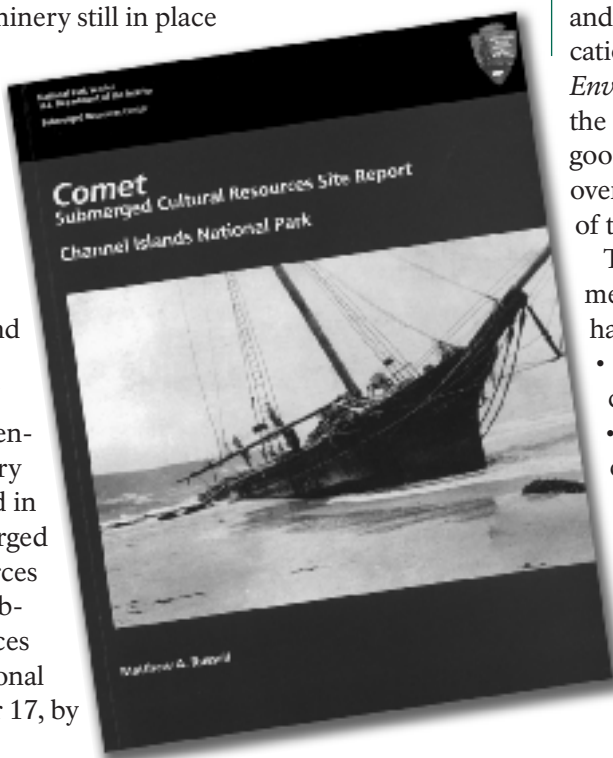
Reference

Houk, R., editor. 2004. *Understanding the life of Point Loma*. Cabrillo National Monument Foundation, San Diego, California.

SHIPWRECK DETAILED IN SUBMERGED CULTURAL RESOURCES REPORT

In March 1999, winter storms at Channel Islands National Park, California, exposed approximately 10% of the wooden hull remains of the Pacific Coast lumber schooner *Comet* on the beach in Simonton Cove, San Miguel Island. This part of the ship had been exposed episodically since the wreck in 1911, most recently in 1984. However, no previous exposures had revealed as much of the well-preserved remains of the ship, considered to be one of the most intact wooden shipwrecks on the Pacific Coast. Recognizing the special opportunity to further document the site, the National Park Service sent a team of archaeologists and volunteers there in April 1999. They found the bow section of *Comet* virtually intact with machinery still in place mounted on the decks. Immediately they set about meticulously recording the wreck in scale drawings, still photographs, and video.

The results of the five-day, intensive documentary effort are shared in “*Comet: Submerged Cultural Resources Site Report*,” Submerged Resources Center Professional Report Number 17, by



Matthew A. Russell. Published in 2004, this monograph is the final report from the 1999 field operations and discusses the results of both historical and archaeological research.

The report summarizes important baseline data regarding the site condition and its significance that can be used for management, interpretation, protection, and future research. The site preserves a regionally important vessel type—the lumber schooner—which is linked to the economic development of major metropolitan areas on the Pacific Coast. The documentary work also encourages regular monitoring of the site, particularly in winter months, to note new exposures when further documentation and study might be possible, and to identify signs of deterioration. This report is an articulate demonstration of the value of often dismissed beached shipwreck remains, particularly when approached with a comprehensive research design and systematic methodology.

The publication includes 36 photos and approximately 25 drawings, and is 95 pages in length. It is available from the NPS Submerged Resources Center in Santa Fe, New Mexico.

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ONE PLANET, MANY PEOPLE: ATLAS OF OUR CHANGING ENVIRONMENT

In celebration of World Environment Day on June 3, 2005, the United Nations Environment Programme (UNEP) in cooperation with the University of Maryland, National Aeronautics and Space Administration (NASA), and U.S. Geological Survey (USGS) announced the publication of *One Planet, Many People: Atlas of Our Changing Environment*. Using satellite imagery and other photos, the atlas vividly illustrates some of the changes—both good and bad—that humans have brought about on Earth over the past 30 years. This is the first publication of some of these satellite images.

The atlas presents visual evidence of global environmental change, including some of the following, that have resulted primarily from human-induced activities:

- Half the world's wetlands were lost during the last century.
- Logging and changes in land use have reduced forest cover by at least 20% and possibly as much as 50%.
- Nearly 70% of the world's major marine fish stocks are either over-fished or being fished at the biological limit.
- Over the last half century, soil degradation has affected two-thirds of the world's agricultural land. Scientists estimate that each year some 250 billion metric tonnes (276 billion tons) of fertile topsoil—

the equivalent of all of the wheat fields in Australia—are lost globally.

- Each year, an estimated 27,000 species disappear from the planet—approximately one every 20 minutes.
- Dams and engineering works have fragmented 60% of the world's large river systems. They have so impeded water flow that the time it takes for a drop of water to reach the sea has tripled.
- Human activities are significantly altering the basic chemical cycles upon which all ecosystems depend.

With respect to the United States, the atlas chronicles the growth of the Fort Lauderdale-Miami area over the past 30 years clearly showing the conversion of farmland into cityscapes and the spread of Miami south and west towards Everglades National Park. Images in the atlas show the massive development of oil and gas wells in the Upper Green River, Wyoming, which is visible from space. On the other hand, one of the most striking features of satellite images of San Francisco, California, is the preservation of its urban forests over the past 30 years.

The images and statistics document the remarkable changes and serve as a warning for environmental events that may occur in the future. The atlas demonstrates how our growing population and its consumption patterns are shrinking our natural resource base. With respect to resource management in the National Park System, *One Planet, Many People: Atlas of Our Changing Environment* may be useful as a basis for developing policy decisions that acknowledge environmental uncertainties and promoting individual actions to help manage resources in a way that sustains natural systems and ensures the long-term well-being of humans and other life-forms.

The complete text and graphics of *One Planet, Many People: Atlas of Our Changing Environment* are available at <http://www.na.unep.net>.

REDUCING ANIMAL-VEHICLE CRASHES

According to statistics posted on the DeerCrash Web site (www.deercrash.com), between 1994 and 2003, 1,472 fatal animal-vehicle crashes occurred in the United States. These crashes resulted in 2,978 human fatalities. The “top ten” states with fatal crashes over this 10-year period were Texas (133), Pennsylvania (69), Wisconsin (68), New York (51), California (50), Georgia (48), Michigan (47), Illinois (46), Missouri (46), and Oklahoma (45).

Assuming that these statistics can serve as proxies for National Park System units, managers of national parks in these states may be interested in the recommendations of researchers from Cornell University and Highway Safety North in Ithaca, New York. Researchers summarize published studies and other information from highway safety,

motor vehicle insurance, and natural resource sources. According to this study (Curtis and Hedlund 2005), which focuses on deer-vehicle crashes, such crashes are seasonal. Crashes involving white-tailed deer peak in October and November during breeding season; a secondary peak occurs in May and June as yearling deer disperse from their birth areas. Deer-vehicle crashes with mule deer are most frequent during the spring and fall migrations. Crashes occur predominantly in darkness, on high-speed, two-lane, rural roads, especially when forest cover is close to the road.

With respect to reducing crashes, the study reports “there is no quick, cheap method.” Control must be part of an overall strategy that balances the competing needs of humans and wildlife. In order to avoid attracting more deer and increasing the number of crashes, coordinated efforts between transportation, natural resource, and urban planning agencies are needed when preserving and creating green space and wildlife corridors.

Hence, data collection and reporting are crucial for defining the problem more precisely and evaluating control methods more accurately. In order to track totals, trends, and patterns, researchers recommend that crash reports include the type of animal involved and the precise location where the crash occurred. Managers should record this information using GIS or other methods in order to identify areas with high animal-vehicle crash frequencies. Collecting and using these data will help focus attention and funding on appropriate areas.

The paper by Curtis and Hedlund identifies three general strategies to reduce animal-vehicle crashes: modify driver behavior, modify deer behavior, or reduce the number of deer. Findings are organized into four categories (table 1): (1) effective methods with solid scientific evidence, (2) promising methods for which more information is needed, (3) methods with limited demonstrated effectiveness, and (4) methods that appear ineffective based on available evidence.

Regarding the information in table 1, fencing combined with underpasses and overpasses is the only method that is proven to be effective in reducing collisions. Unfortunately, this is also the most expensive method. Although more research is needed on the minimum area necessary for herd reduction to have a substantial effect, this method appears to be effective in decreasing the number of crashes in a specific area when a herd is substantially reduced. Because wildlife viewing is an important visitor activity in the National Park System, herd reduction would need to be part of an overall wildlife management program that balances the costs and benefits of maintaining wildlife populations. Some authors suggest that deer may be attracted to roadways by salt applied to melt ice in the winter and that other deicing substances should be used instead. However, no studies have investigated this



DETERRING “NUISANCE” BLACK BEARS: AN EVALUATION OF COMMON TECHNIQUES

Table 1. Methods and efficacy of reducing animal-vehicle crashes

Effective methods with solid scientific evidence

Fencing combined with underpasses and overpasses

Promising methods for which more information is needed

Herd reduction

Temporary (posted only during migration periods) passive signs

At-grade crossings (with fencing and landscaping that directs deer* to crosswalks) combined with active signs (e.g., with flashing lights)

Methods with limited demonstrated effectiveness

Reflectors

Roadside lighting

Intercept feeding

Repellents

Methods that appear ineffective based on available evidence

General education

Passive signs

Lower speed limits

Deer whistles

Deer flagging

Source: Curtis and Hedlund (2005).

*Particularly promising for mule deer in western states.

issue. Finally, general education about animal-vehicle crashes is unlikely to be useful unless it provides information on very specific and time-sensitive situations, such as the beginning of mule deer migration across a short road segment. In these situations, either temporary passive or active signs may be more effective than general campaigns. In short, a general-information flyer handed out regularly with a park newspaper is probably not going to help reduce animal-vehicle crashes.

In addition to Curtis and Hedlund (2005), a few other sources are recommended reading for resource managers in areas with high animal-vehicle crash frequencies (see references). The DeerCrash Web site also contains an extensive bibliography that is updated periodically with summaries of information on specific crash avoidance methods.

References

Curtis, P. D., and J. H. Hedlund. 2005. Reducing deer-vehicle crashes. Wildlife damage management fact sheet series, Cornell Cooperative Extension, Ithaca, New York.

Danielson, B. J., and M. W. Hubbard. 1998. A literature review for assessing the status of current methods of reducing deer-vehicle collisions. Iowa Department of Transportation and Iowa Department of Natural Resources.

Putman, R. J. 1997. Deer and road traffic accidents: Options for management. *Journal of Environmental Management* 51:43–57.

Primarily in response to public outcry for nonlethal management actions of “nuisance” bears at urban-wildland interface areas, land managers in the United States and Canada increasingly implemented a variety of bear deterrence techniques during the 1990s. Many states and other entities such as national parks dedicate considerable staff and funding to deter bears that frequent urban or developed park areas. The six most common techniques that management agencies use to alter the behavior of nuisance bears are rubber buckshot, rubber slugs, pepper spray, cracker shells, dogs, and loud noises. However, prior to Beckman et al. (2004), no research had rigorously analyzed the efficacy of these deterrents. The study area was the Lake Tahoe basin in the Sierra Nevada mountain range in western Nevada, where human population increased by 26% between 1990 and 2000, and the number of complaints by citizens concerning black bears increased more than tenfold.

Researchers trapped and collared 62 bears that they randomly assigned to one of three experimental groups: (1) received deterrents, (2) received deterrents and were chased by dogs (hounds), and (3) received no deterrents (control group). Researchers moved the bears varying distances (2–50 miles [1–75 km]) from the capture site to administer deterrents.

In 92% (57 of 62) of the cases, bears returned to the urban area where they were captured. Of the 62 bears, 33 (53%) returned in less than 30 days, 17 (27%) returned between 31 and 180 days, seven (11%) returned between 181 and 365 days, and five (8%) had not returned in more than 365 days. These results suggest that bears that are conditioned and habituated to human garbage and live near or in urban-wildland interface areas were unlikely to alter their behavior in response to the deterrent techniques currently used by most state and federal agencies. Hence, researchers of this study recommend that any group dealing with “nuisance” bears conduct a cost-benefit analysis to decide whether monetary investment in deterrents is worthwhile.

Before abandoning all deterrent techniques, however, the researchers stress the importance of how an agency defines success in deterring nuisance bears. If the goal is to never have to deal with a nuisance bear again, then the data from this study suggest that this particular outcome is doomed to failure. If, on the other hand, the goal is to establish positive public relations or to avoid dealing with an individual bear for several week or months (perhaps during times of high human visitation), then deterrents may be an effective management tool. For example, according to Beckman et al., a combination of ordinances

and public education has been successful in reducing the number of conflicts between bears and humans in Juneau, Alaska, and Yosemite National Park, California. Hence, a program that implements the use of nonlethal deterrents may provide an opportunity for increasing public awareness while decreasing the number of human-bear conflicts created by the availability of human food sources.

Reference

Beckman, J. P., C. W. Lackey, and J. Berger. 2004. Evaluation of deterrent techniques and dogs to alter behavior of "nuisance" black bears. *Wildlife Society Bulletin* 32(4):1141–1146.

VOLUNTEERS AND MAMMAL MONITORING: AN EFFECTIVE COMBINATION?

The National Park Service and many conservation organizations rely heavily on volunteers to achieve tasks for which funding is limited. Moreover, information gathered by non-professionals completes many research projects. Nevertheless, attempts to calibrate the effectiveness of volunteers and validate the collected data are rare. To address this concern, Newman et al. (2003) assessed 155 volunteers and the data they collected during a mammal monitoring project at Wytham Woods, Oxfordshire, England. Volunteers came from various social and educational backgrounds: students, professionals, retired, probation services, and drug rehabilitation programs, and from both inside and outside Britain.

The study revealed that gender, training, previous experience, and physical fitness had significant effects on volunteer suitability for several different tasks, whereas age and mental aptitude had no influence on volunteer performance.

Gender—Men performed significantly better than women in mammal monitoring methods, for example, finding deer droppings in experimental quadrants. As it happens, the highest and lowest scores were both women, but the variance in the median scores was consistently higher in women than it was in men. Generally, women in the sample were more hesitant than men, and sometimes had to be persuaded to perform certain tasks such as handling mice or touching deer droppings. This hesitancy set these individuals back relative to their contemporaries, reducing their overall ability to perform the task.

Training—Practical field training and demonstrations proved essential for all monitoring techniques used in this study. Without this training, volunteers were generally unable to perform the required tasks (even when supplied with written instructions).

Background and previous experience—People from disadvantaged backgrounds, as exemplified in the sample by

those from drug rehabilitation programs, showed no hesitation to undertake certain tasks; indeed, they were generally among the highest scoring volunteers. Although previous experience did not improve the success rate of volunteers (e.g., finding deer droppings), experienced volunteers took significantly less time to carry out surveys.

Physical fitness—Overall fitness had a significant influence on the mean perceived usefulness and capacity of volunteers, with fitter people being perceived by the researchers to be better suited to the tasks than less fit people.

This study found that with appropriate training, volunteers were able to perform tasks reliably and accurately. Basic training consisted of a half day per focal species, including background theory, practical demonstration, and initial close supervision of volunteers (as a cautionary measure to ensure animal welfare and volunteer safety). Researchers emphasize the importance of training, albeit time consuming. They explain that many volunteers can be trained simultaneously, which represents a time- and cost-effective method for ultimately increasing the number of people able to continue to collect scientific data for wildlife conservation, especially if the trained volunteers are able to make a long-term commitment to a wildlife conservation project.

Reference

Newman, C., C. D. Buesching, and D. W. Macdonald. 2003. Validating mammal monitoring methods and assessing the performance of volunteers in wildlife conservation—“*Sed quis custodiet ipsos custodiet?*” *Biological Conservation* 113:189–297.

WORLD'S FASTEST FLOWER

Does bunchberry dogwood (*Cornus canadensis*) grow in your park? If it does, you can now boast that your park hosts the world's fastest plant. The flower's stamens catapult pollen into the air as the flower opens explosively. According to Edwards et al. (2005), bunchberry dogwood stamens serve as miniature medieval trebuchets—specialized catapults that maximize throwing distance by having the payload (pollen in the anther) attached to the throwing arm (filament) by a hinge or flexible strap (thin vascular strand connecting the anther to the filament tip). This floral trebuchet enables stamens to propel pollen upwards faster than a simple catapult.

High-speed video observations show that the flower opens in less than 0.5 millisecond (ms) (i.e., half a thousandth of a second). This is the fastest movement recorded in a plant. The process of petal opening and pollen launching in *Cornus canadensis* occurs faster than the opening of *Impatiens pallida* fruits (2.8–5.8 ms), the snap



of Venus flytraps (*Dionaea muscipula*, 100 ms), the leap of froghoppers (*Philaenus spumarius*, 0.5–1.0 ms), or the strike of the mantis shrimp (*Odontodactylus scyllarus*, 2.7 ms) (Edwards et al. 2005).

Bunchberry dogwood bears flowers much like those of the ornamental dogwood tree, but this plant is a shrub. Its tiny flowers span only a few millimeters and cluster at the center of four white leaves, which resemble petals. The plant grows in dense carpets in the vast spruce-fir forests that span the northern half of the United States from New York to Washington. The Natural Resources Conservation Service also lists the flower as occurring in Alaska, Wyoming, Colorado, and New Mexico. The plant is listed as endangered in Illinois, Indiana, and Maryland, and as threatened in Iowa and Ohio.

So what's the point, besides being able to say that your park hosts the "fastest flower in the West" (or wherever else it may be growing)? Exploding flowers such as bunchberry dogwood enhance insect pollination and may allow for wind pollination. Indoors, pollen of the bunchberry dogwood is transported nearly 9 inches (22 cm), which is more than 100 times the size of the flower; outdoors, in the presence of a steady wind, pollen can move farther than a meter. Information about this record-breaking catapult adds to growing evidence that flowers often use multiple pollination mechanisms (Edwards et al. 2005).

References

- Edwards, J., D. Wiltaker, S. Klionsky, and M. J. Laskowski. 2005. A record-breaking pollen catapult. *Nature* 435 (12 May 2005):164.
- Milius, S. 2005. World's fastest plant explodes with pollen. *Science News* 167(24):381.

TO CORE OR NOT TO CORE? THAT IS THE QUESTION.

Collecting cores from trees is a standard method for measuring ages and growth in seasonal environments where annual tree rings are formed (van Mantgem and Stephenson 2004). Tree coring is also widely used for studying fire histories on landscape scales. For example, in the San Juan National Forest in Colorado, researchers are studying how fire regimes and forest structure have varied across space and time in response to regional climate variability and land-use change. The project status (8 July 2005) indicates that researchers have sampled cores (or cross sections) from approximately 3,700 trees (Brown and Wu 2005). Taking tree cores also occurs in national park areas. For example, in 1995 *Park Science* reported that researchers collected cores from pure stands of aspen (*Populus tremuloides*) adjacent to mixed

conifer sites at Bandelier National Monument in New Mexico in order to determine post-fire establishment dates (Allen et al.). This standard research practice enables a variety of management and research questions to be addressed. But does it contribute to tree mortality? As highlighted in van Mantgem and Stephenson, this question has not been answered satisfactorily.

The authors used 21 years of annual-resolution data from two cored and two un-cored permanent plots in the Sierra Nevada of California. The objective was to detect change in mortality rates 12 years following coring for two coniferous species: white fir (*Abies concolor*) and red fir (*Abies magnifica*). Analysis of data from these sites supports the idea that coniferous trees sustain little serious damage from tree coring. However, several caveats apply to these results. First, a post-coring interval of 12 years is short compared to the more than 300-year potential lifespan of these species. Second, the cored trees may have sustained internal and unobservable damage, resulting in fungal infections, which could cause future elevated mortality rates. Third, under more challenging conditions (e.g., drought, windstorms, or pathogen outbreaks) coring damage could become a contributing factor of tree death. Fourth, other species, in particular hardwoods, are likely to show greater susceptibility to fungal attacks following coring, possibly leading to mortality.

If coring has a measurable effect on tree mortality, it may be important to consider how it shapes subsequent forest dynamics and limit its use to situations where destructive sampling is considered acceptable (van Mantgem and Stephenson 2004). Hence, this study recommends more research to conclude categorically that coring does not cause significant harm. The article suggests that a promising avenue for future research would be to exploit information from historical and ongoing projects (of which plenty seem to be available).

References

- Allen, C. D., R. Touchan, and T. W. Swetnam. 1995. Landscape-scale fire history studies support fire management action at Bandelier. *Park Science* 15(3):18–19.
- Brown, P. M., and R. Wu. 2005. Fire and forest structure across vegetation gradients in San Juan National Forest, Colorado: a multi-scaled historical analysis. Project summary and project status (8 July 2005). Rocky Mountain Tree-Ring Research, Inc., Fort Collins, Colorado. Available at <http://www.rmtrr.org/SJNF/SJNFfirehistory.html> (accessed 4 August 2005).
- van Mantgem, P. J., and N. L. Stephenson. 2004. Does coring contribute to tree mortality? *Canadian Journal of Forest Research* 34:2394–2398.

ARE UGLY PARKING LOTS HEALTHIER?

Parking lot sealants, also called “sealcoat,” are applied to many parking lots and driveways in an effort to protect the underlying asphalt pavement and enhance appearance. However, the sealants contain concentrations of polycyclic aromatic hydrocarbons (PAHs)—a group of widely recognized carcinogenic aquatic contaminants. According to the U.S. Environmental Protection Agency, PAHs adversely affect mammals (including humans), birds, fish, amphibians, invertebrates, and plants. In aquatic environments, the effects of PAHs on invertebrates include inhibited reproduction, delayed emergence, sediment avoidance, and mortality, and the effects on fish include fin erosion, liver abnormalities, cataracts, and immune system impairments (U.S. Environmental Protection Agency 2003).

Mahler et al. (2005) reveals parking lot sealant as a previously unidentified source of PAHs that may be the dominant source of PAHs in watersheds with residential and commercial development. Other sources of PAHs include automobile exhaust, lubricating oils, gasoline, tire particles, erosion of street material, and atmospheric deposition. With the exception of the sealant itself, unsealed parking lots receive PAHs from the same urban sources as sealed parking lots, yet the average yield of PAHs from sealed parking lots is 50 times greater than that from unsealed lots (Mahler et al. 2005). Adding to these concentrations, manufacturers recommend that sealant be reapplied every two or three years because it abrades relatively rapidly from parking-lot surfaces.

The revelation of this study is that although previously identified sources of PAHs, such as automobile exhaust and atmospheric deposition, have been difficult to control or even quantify because of their non-point nature, sealed parking lots are now a recognized point source. This realization provides a means for reducing PAHs to aquatic systems because the use of parking lot sealant is voluntary and controllable.

References

- Mahler, B. J., P. C. Van Metre, T. R. Bashara, J. T. Wilson, and D. A. Johns. 2005. Parking lot sealant: an unrecognized source of urban polycyclic aromatic hydrocarbons. *Environmental Science & Technology* 39(15):5560–5566.
- U.S. Environmental Protection Agency. 2003. Information on the toxic effects of various chemicals and groups of chemicals. Available at <http://www.epa.gov/R5Super/ecology/html/toxprofiles.htm#pahs> (accessed 4 August 2005).

URBAN WILDLIFE, ECOSYSTEMS, AND HUMAN HEALTH

The year 2003 was the first in which more people lived in urban areas than rural ones. By 2050 perhaps as many as three-fourths of the world’s human population will live in cities and suburbs (Cohn 2005). As cities grow in areal extent and human occupation, parks in urban areas become increasingly important for the environmental values, such as wildlife, they preserve and for benefiting human populations where they live.

Cohn points out that urban parks harbor a variety of wildlife, including animals not normally thought of as “city critters.” For example, flying squirrels, red-backed voles, and a rare moth found nowhere else inhabit Pelham Bay Park in the northeastern part of the Bronx in New York City. Though Cohn focuses on New York City, which includes parts of Gateway National Recreation Area, the recognition that wild places and wildlife can be found in urban settings throughout the National Park System is important for our expanding human population. The National Park System contains urban parklands such as Fire Island National Seashore, New York, Cuyahoga Valley National Park between Cleveland and Akron, Ohio, and Rock Creek Park in Washington, D.C. Cohn discusses how wildlife, ecosystems, and human health are related in urban settings. A few examples are highlighted here.

Seabirds, which are at the top of the food chain, are good indicators of pollutants. According to Cohn, the health of seabirds serves as an advance warning for people who eat fish and shellfish from the same waters as the birds. A significant human impact that affects seabird populations is plastic. Because many seabird species feed on fish and crustaceans at the ocean’s surface, they are particularly prone to contact with floating plastic. Ingested plastic seems to be killing more seabirds than oil or other pollutants.

Carrion and dung beetles remove and recycle waste materials, which if left on the ground could become sources of disease. By eating dung, the beetles kill bacteria and protozoa that can cause disease in people. However, in order for beetles to remove and recycle waste, they need soft “functioning” soil. The hard surfaces (e.g., streets, parking lots, and sidewalks) and compacted soils of urban and suburban areas are not favorable for beetle habitats.

The diversity of bird and mammal populations is important for human health because diversity decreases disease. As a case in point, the number of white-footed mice is growing as the number of other mammals and birds decline in fragmented patches of urban forest. This species is the best reservoir for Lyme disease. More than



90% of ticks that feed on white-footed mice become infected with the pathogen that causes the disease, while at most 50% get the pathogen from feeding on other species. Hence, the simple conclusion is that the more diverse bird and mammal populations are, the fewer ticks will be infected and the less likely humans will be to get the disease.

As Cohn illustrates, an increasing number of university researchers, conservation groups, and wildlife biologists have begun to recognize the significance of wildlife in urban “wild places.” Urban wildlife species not only serve as indicators of ecosystem health, but provide health to the increasing number of people living in metropolitan areas.

Reference

Cohn, J. P. 2005. Urban wildlife. *BioScience* 55(3):201–205.

FULL AND NEW MOONS COULD INFORM MONITORING PROGRAMS

Managers of marine recreational beaches routinely monitor for fecal indicator bacteria (FIB) such as enterococci. These bacteria cause an increased risk for bathers in acquiring gastrointestinal illness and other ailments. Water quality is typically monitored in early morning once a week without respect to tidal conditions (Boehm and Weisberg 2005). When samples exceed regulatory limits, managers temporarily close beaches. One problem with the present monitoring protocol is that FIB concentrations change at frequencies that surpass those at which posting decisions can be made. In other words, managers may be too late in detecting a pollution event; the health hazard may be gone by the time they post health advisories.

To assess the effect of tides on water quality, which informs the public health warning system, researchers analyzed data from monitoring programs in three regions of southern California, including Huntington Beach, Whites Point, and Santa Monica Bay. Researchers assembled years of data from 60 beaches spanning 75 miles (120 km).

At most sites (50 beaches), enterococci concentrations were significantly higher during spring tides (associated with full and new moons), especially during ebbing, than during neap tides (associated with the moon’s first and third quarters). Moreover, enterococci concentrations that exceeded standards were typically more than twice as likely to occur during spring tides as compared to neap tides. Researchers also considered a beach’s geomorphology, orientation, and the proximity to terrestrial runoff sources. However, according to Boehm and Weisberg, these factors had minimal influence on the tidal modulation of enterococci concentrations.

Spring tides have the maximum tidal range in an area and, thereby, provide the greatest exchange between terrestrial (surface and ground) waters and coastal waters. Neap tides have the minimum tidal range for an area. Hence, it may not be surprising that higher concentrations of enterococci occur during spring tides because these tides affect a greater terrestrial area. Possible terrestrial sources of enterococci include enterococci-laden groundwater (saline and fresh) from the beach aquifer, enterococci-enriched sands, decaying wrack, and bird feces near the high water line. This study suggests that enterococci delivered by tidally forced sources other than terrestrial surficial runoff are widespread, showing the importance of including tides in the design and interpretation of beach-water monitoring programs.

Reference

Boehm, A. B., and S. B. Weisberg. 2005. Tidal forcing of enterococci at marine recreational beaches at fortnightly and semidiurnal frequencies. *Environmental Science & Technology* 39(15):5575–5583.

BIODIVERSITY THROUGH TIME

Typically we do not consider fossils as being relevant for assessing the conditions of present-day ecosystems in the National Park System. However, researchers often lament that the lack of long-term data is a critical gap in their knowledge, and resource managers dream of long-term records upon which to base their resource management decisions. Willis et al. (2005) points out that long-term data is available but is not filtering through to people assessing biodiversity. The article states that “contrary to popular belief, it is possible to obtain high-resolution temporal and taxonomic analyses that reveal annual variations in communities over hundreds to thousands of years.” The source is paleoecology.

Paleoecological research includes the use of fossil packrat middens and fossil pollen. Paleoecological data from packrat middens and other natural archives have been useful for defining baseline conditions of vegetation communities, determining histories and rates of species range expansions and contractions, and discriminating between natural and cultural causes of environmental change (Swetnam et al. 1999).

Basing a decision on a 50-year record, for instance, may be acceptable for some herbaceous plants and animals. However, the average generation time of many organisms, such as trees, is greater than this. Hence, the use of longer-term data is often necessary for managing present-day ecosystems. Paleoecology may provide the very information that resource managers need (e.g., time-series data, data on abundance and how it varies, and long-term distribution data). Willis et al. (2005) argues that

managers should routinely incorporate long-term records into planning and management frameworks to provide a direct measure of ecosystem changes through time.

References

Swetnam, T. W., C. D. Allen, and J. L. Betancourt. 1999. Applied historical ecology: using the past to manage for the future. *Ecological Applications* 9(4):1189–1206.

Willis, K. J., L. Gillson, T. M. Brncic, and B. L. Figueroa-Rangel. 2005. Providing baselines for biodiversity measurement. *Trends in Ecology and Evolution* 20(3):107–108.

HOW GIS ENHANCES SCIENCE IN THE PARKS

A recent book from ESRI Press displays the myriad uses of geographic information systems (GIS) technology in the national parks. *Mapping the Future of America's National Parks: Stewardship through Geographic Information Systems*, edited by Mark Henry, an editor at ESRI Press, and Leslie Armstrong, former GIS Program manager at the National Park Service, is a big, elegant, sampler demonstrating the many kinds of maps that GIS has produced to illuminate a great variety of management issues in the national parks. Each example is treated with a paragraph of explanation, photos of the landscape or other relevant scenes in the park, and a sample of the maps created to address the desired objective.

For example, at Saratoga National Historical Park in New York, where American forces defeated the British in 1777, GIS maps have been developed to show visitors the movement of troops, events leading to the British surrender, and how features of the landscape determined the military strategies of both armies. GIS mapping thus enhanced the visitor experience, and it also played a role in helping the park to plan the restoration of key landscapes as they existed in 1777 and in selecting the best viewing areas for visitors.

A very different example shows nitrous oxide pollutants moving from Seattle through the Puget Sound basin and over Mount Ranier National Park. From a series of maps representing this movement during one typical summer day, GIS technicians made an impressive animation of the movement of the pollution that damages plant and marine life and degrades scenic vistas. This is the kind of natural

resource visualization that demonstrates the special capabilities, and the importance, of GIS technology.

To assist parks in remote Alaska, where Internet access may be problematic in some parks and GIS specialists may not be available on site, the National Park Service has created some relatively easy-to-use tools: NPS Theme Manager accesses more than 1,500 themes, or layers, for Alaska parks; AlaskaPak Toolkit is a collection of tools for novice users; NPS Firepak lets users create a standardized data set and map wildfire perimeters; and ArcView to Access Link sets up a live link between GIS maps and computer databases.

After perusing this book about all that GIS can do in the parks, some readers are likely to be thinking about how they could put such easy-to-use software to use in their own projects.

Reference

Henry, M., and L. Armstrong, editors, in cooperation with the National Park Service. 2004. *Mapping the future of America's national parks: Stewardship through Geographic Information Systems*. ESRI Press, Redlands, California.

NORTHEAST PARK INVENTORIES ON THE WEB

As Northeast Region park inventories of wildlife and water and air quality are completed, the reports of these surveys are posted on the Web site for science in the parks in the Northeast (<http://www.nps.gov/nero/science>). Two recent postings are notable. One is *Data Review and Synthesis of Natural Resources Information from Cedar Creek and Belle Grove National Historical Park*, which reports on a new park in Virginia established in 2002. Another report of interest to natural resource managers dealing with disparate data being collected from many

taxon-specific surveys is *Biodiversity Inventory: Approaches, Analysis, and Synthesis*. This report reviews analytical and statistical tools used to integrate biodiversity data and provides recommendations for analyzing these data in a way that is useful for managers developing general management and resource management plans. All reports can be accessed from <http://www.nps.gov/nero/science/FINAL/finalreps.htm>.



notes
from *abroad*

HIGHWAYS AND WILDLIFE: HABITAT FRAGMENTATION AND COLLISION MORTALITY

Challenges and solutions in Banff National Park, Canada

By **Bruce F. Leeson**
and
Erin Burrell

The die was cast for how humankind would utilize and travel through Canada's Rocky Mountain cordillera when the glaciers retreated 11,000 years ago. Glacially carved U-shaped valleys became critical travel routes for wildlife, and later, human explorers and settlers. Road and rail travel routes were pioneered and have had increasing use since the 1880s. In the 1970s, a conflict between modern travel expectations and resource management erupted in Banff National Park, Alberta, and has continued to this day. This conflict has caused Parks Canada to employ innovative measures for the protection of wildlife in Banff, Canada's first national park. Now a world heritage site, Banff remains rich in its original assemblage of Rocky Mountain wildlife (fig. 1).



Figure 1. The conflict between modern travel and animal migration caused Parks Canada to employ innovative measures for the safe passage of wildlife across parts of the Trans-Canada Highway, which transects Banff National Park. Banff is a world heritage site and retains its original assemblage of Rocky Mountain wildlife, including cougar, grizzly, coyote, and wolf. PARKS CANADA (4)

The problem

The Trans-Canada Highway, probably the most important highway in the nation, transects the Bow Valley of Banff National Park—a montane and subalpine environment important to the sustenance of 12 species of large mammals and myriad smaller species. By the 1970s the highway had become known as the “Meatmaker” because of the large number of wild animals, primarily elk, killed by vehicular traffic each year (fig 2). Safety concerns associated with increasing traffic volume, along with expectations for increased speed, demanded that the roadway be upgraded. Because of the need to protect the pristine habitat that the highway traversed, proponents of traditionally mutually exclusive goals began to work together to find engineering solutions that effectively integrated ecological considerations. Rather skeptical stakeholders conducted an unusually transparent forum for research, planning, and design. Planners strategized about how to meet extraordinary budget requirements to fund exceptional elements of nontraditional highway construction.

The Trans-Canada Highway, probably the most important highway in the nation, transects the Bow Valley of Banff National Park.

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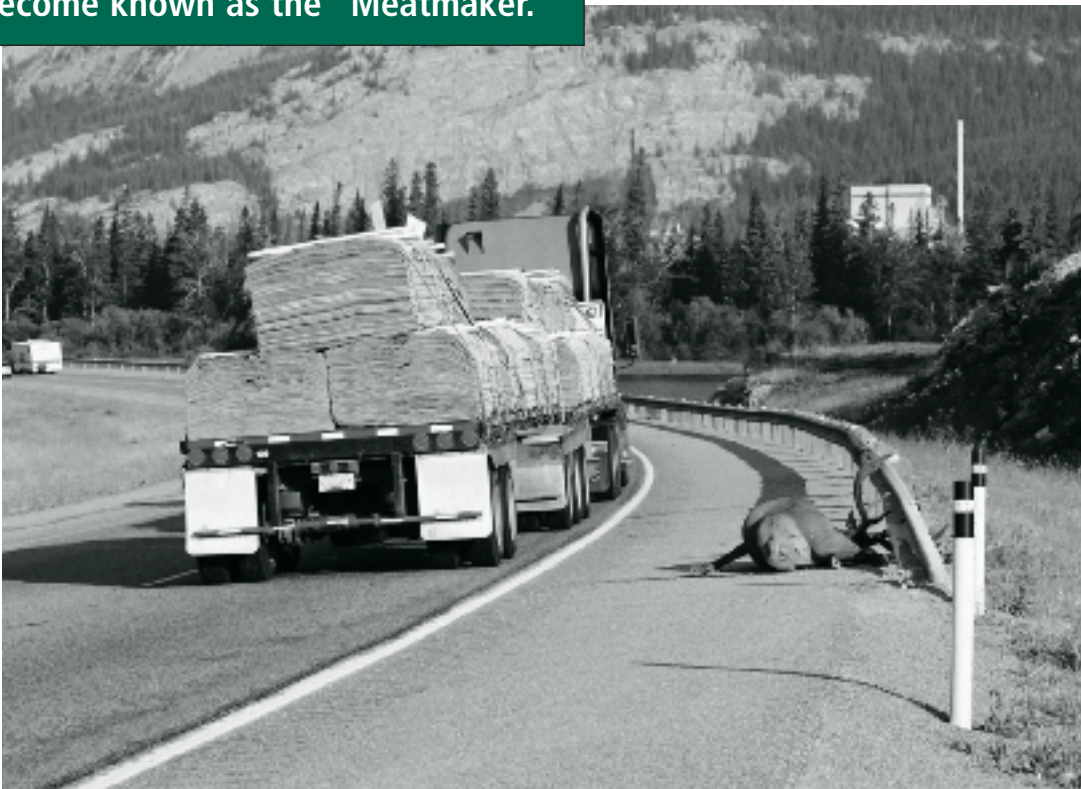


Figure 2. Prior to the erection of highway fencing, the Trans-Canada Highway in Banff National Park was known as the “Meatmaker” because of the number of vehicle-wildlife collisions that occurred on the road. Elk were the primary victims in these accidents. GREG BELLAND

The project

Construction began in 1979 and continued in phases until 1997. To date, 28 miles (45 km) of highway have been “animal proofed,” involving 21 underpasses and 2 overpasses along with 8-foot- (2.4-m-) high fences (fig. 3, page 24). Some of the fences are combined with buried aprons to prevent animals from digging their way under. Construction also includes the use of cattle guards on secondary roads and pedestrian gates through the fences at frequently used locations. From the beginning of the project to 1997, Parks Canada spent about \$85 million (Canadian), with environmental budget components increasing from 16% of the original phase to 20% and 30% of subsequent phases.

Performance and research

Parks Canada was obliged to study the performance of the works and undertake remedial interventions as needed. In the time since the last phase was completed, track recording and instrumentation has documented more than 63,000 wildlife passages by animals coyote size or larger through the crossing structures (table 1, page 24); investigators have confirmed that all native species with

home ranges in the glacial valleys have made passages. Wildlife collisions on the fenced portion of the roadways have been dramatically reduced; for example, in the case of elk, collisions have decreased by 96%. Traffic flow and vehicle transit times have improved, and serious traffic accidents have declined. Research associated with the project has produced numerous MS and PhD degrees and dozens of technical articles. Planners, engineers, resource managers, and biologists from around the world have attended conferences and tours that focus on the project.



Table 1. Wildlife and human crossings of the Trans-Canada Highway between Banff National Park (east gate) and Castle Junction, November 1996–March 2005

Animal	Box culvert (4)	Elliptical culvert (6)	Open-span underpass (8)	Creek bridge (3)	Overpass (2)	Total
Black bear	81	200	467	60	35	843
Cougar	64	144	541	124	39	912
Coyote	667	846	2,723	422	227	4,885
Deer	324	3,960	11,855	975	5,077	22,191
Elk	506	2,854	21,885	999	1,241	27,485
Grizzly bear	5	10	112	6	72	205
Moose	0	2	22	2	32	58
Sheep	0	1	2,893	11	0	2,905
Wolf	85	370	2,795	212	115	3,577
Total	1,732	8,387	43,293	2,811	6,838	63,061
Human use	90	263	9,860	432	62	10,707

Source: Dr. Tony Clevenger for Parks Canada.



Figure 3. Banff National Park now has two multispecies overpasses that are part of a network of linkages designed to minimize the impacts of the Trans-Canada Highway on wildlife. Research has shown that human use of wildlife crossing structures has a greater impact on carnivore use than either placement or structural characteristics of the crossing. BRUCE LEESON, PARKS CANADA

We have learned a great deal about what works and what does not for this kind of project. These lessons are helping to guide future wildlife mitigation projects. For example, research has shown that human use of wildlife crossing structures has a greater impact on carnivore use than either placement or structural characteristics of the crossings, highlighting the importance of concurrent public education. When human use is not a factor, different species tend to prefer different types of structures. These preferences are in keeping with the natural history characteristics of particular species. For example, cougars and black bears tend to prefer darker, smaller crossings with vegetative cover at the access and egress, while ungulates and grizzly bears prefer bright, wide passages in open topography, allowing for long lines of sight. (Detailed research findings are discussed in the articles listed in the reference section.)

Projects of this type involve the integration of diverse scientific, engineering, legal, and political considerations and also may require effective partnerships, interjurisdictional cooperation, communication, and meaningful involvement of stakeholders and citizen advocates. However, the benefits are proven and extensive, and not restricted to the human travelers and wildlife on the roadway. New positive relationships have developed between traditional antagonists as many skeptics and critics have been converted to believers and supporters. In general, this initiative has helped raise awareness about ecology and transportation issues in other government departments and jurisdictions. A promising side benefit is the increased stewardship ethic that the project has engendered in visitors and nearby residents to the national park.

Current and future activities

The success of Parks Canada's initiative in Banff National Park has influenced planners and managers in other locations. Organizers of the 2002 G8 Summit held in Kananaskis—a protected wildland area adjacent to Banff—were so impressed with this stewardship accomplishment that the Canadian government established a legacy to construct similar wildlife connectivity works on provincial lands east of Banff. Here, the con-

struction of a wildlife bridge over a canal and an underpass at a primary wildlife corridor on the Trans-Canada Highway will address critical habitat linkages and factors affecting passage by wildlife (fig. 4).

With 4.5 million visitors and 5 million through-travelers annually in Banff National Park, Parks Canada is currently engaged in research and planning to extend this world-leading highway project another 20 miles (33 km). The environmental components for this latest phase comprise one-third of the budget and will involve construction of an additional 18 wildlife crossing structures and associated highway fencing. Parks Canada has budgeted \$50 million (Canadian) for the first 6 miles (10 km) of the project, with eight new wildlife crossing structures. Construction began in February 2005.

While the emphasis on integrating transportation and wildlife management addresses an acute problem, the efforts to preserve connected movement routes for wide-ranging mammal species also fit into a wider context in the Bow Valley and beyond. Provincial and municipal planners have been working with private developers on lands adjacent to Banff National Park for more than a decade to preserve wildlife corridors and educate the public about their stewardship responsibilities. On a

See "Notes from Abroad" in right column on page 42

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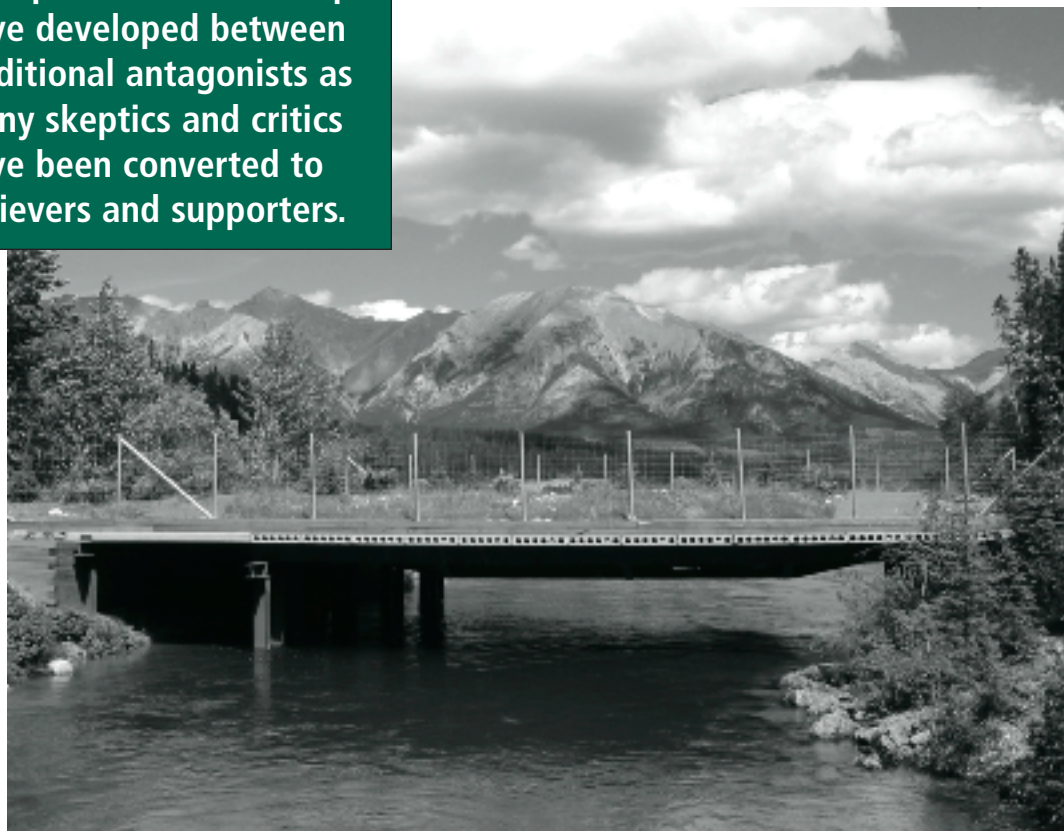


Figure 4. As part of the overall mitigation of restoring habitat continuity, Parks Canada constructed a wildlife bridge over a canal near Banff National Park. This particular bridge is a legacy of the G8 Summit held in Kananaskis, Alberta, in 2002. BRUCE LEESON, PARKS CANADA



DEVILS HOLE REVISITED

WHY ARE PUFFISH NUMBERS AND WATER LEVEL DROPPING AGAIN?

By John G. Wullschleger
and
William P. Van Liew



Figure 1. The tiny Devils Hole pupfish is less than an inch (2.5 cm) long but has played a big role in native species conservation.

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The diminutive Devils Hole pupfish (*Cyprinodon diabolis*, fig. 1) in Death Valley National Park (California and Nevada) has played an outsized role in the history of native species conservation, including helping to motivate one of the earliest uses of federal reserved water rights to protect habitat

of a species of no recreational or commercial value. However, water levels in Devils Hole are dropping and species numbers are declining (fig. 2). After more than three decades of research and monitoring, managers and researchers still do not have a complete understanding of the ecosystem of Devils Hole.

BACKGROUND

Located 30 miles (48 km) east of Death Valley in the Amargosa Desert of Nevada, Devils Hole is administered as a unit of Death Valley National Park. Geologically, Devils Hole is a surface collapse depression into a fault-controlled open fracture in Paleozoic limestone. Viewed from above, the site appears as a roughly conical depression at the base of a group of low desert hills. From the rim, the opening narrows downward to the surface of a pool, approximately 10 feet (3 m) wide by 60 feet (18 m)

long, and 49 feet (15 m) below the surrounding land surface (fig. 3). A high chain-link fence surrounds the entire opening. Although the surface of the pool appears to indicate the bottom of the hole, nothing could be further from the truth. The

Beyond the edge of the shelf, the bottom drops away into a network of submerged caverns, which no one has fully explored.

southern portion of the pool (16 feet x 10 feet [4.9 m x 3 m]), referred to as the “shallow shelf,” overlies a large boulder; beyond the edge of the shelf, the bottom drops away into a network of submerged caverns, which no one has fully explored. The pool is a surface expression of a vast, regional carbonate-rock aquifer system that underlies a substantial portion of Nevada.

When miners traveling to California’s gold fields in 1849 discovered Devils Hole and paused to bathe in its warm (about 90°F [32°C]), clear waters, they found they

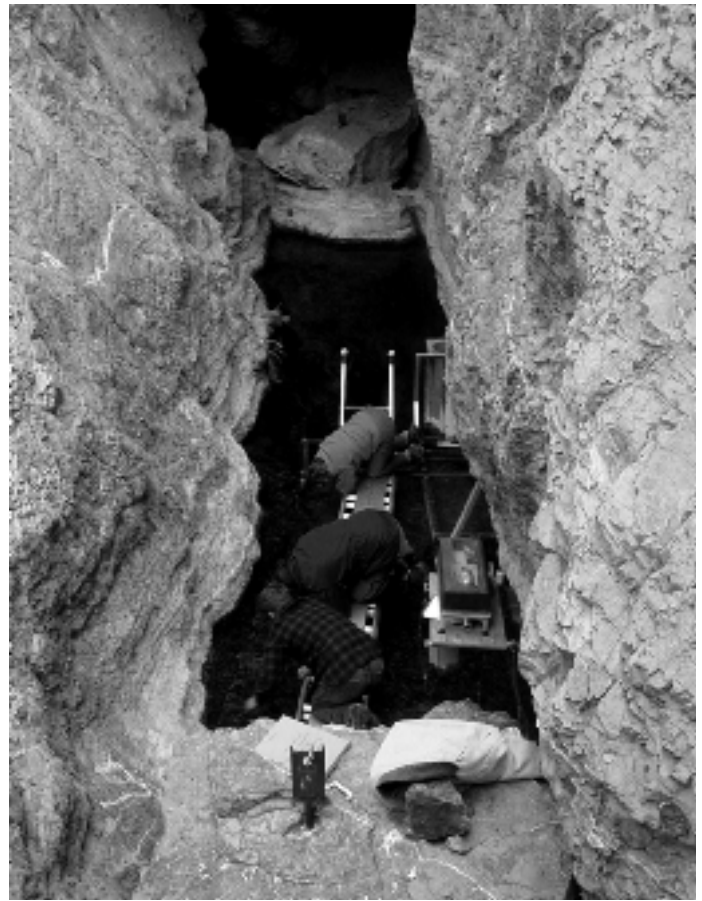


Figure 3. From the rim, the opening to Devils Hole narrows downward to the pool, which is a surface expression of a regional aquifer that underlies a substantial portion of Nevada. Devils Hole may be the smallest habitat in the world occupied by an entire vertebrate species.

NPS/JOHN WULLSCHLEGER

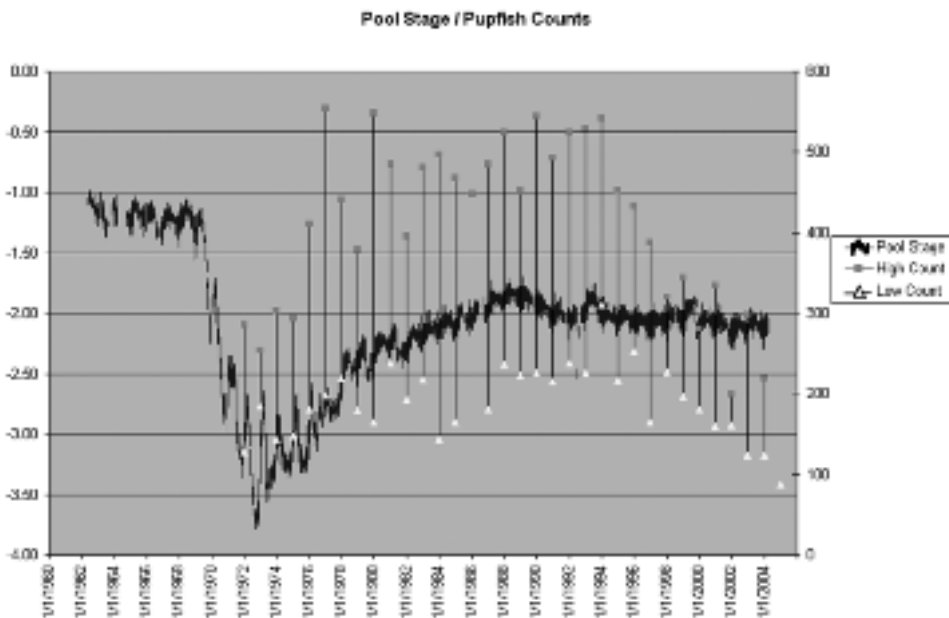


Figure 2. Pupfish numbers fluctuate annually with highs typically occurring in the fall (often October) and lows in the spring (usually April). Investigators have been measuring water levels and pupfish numbers since 1962. The current trend at Devils Hole is that water level is dropping and pupfish numbers are declining. In the graph the left axis represents pool stage measured in feet below a reference point (copper washer); the right axis denotes the number of individual pupfish counted.

DATA SOURCE: NATIONAL PARK SERVICE AND U.S. GEOLOGICAL SURVEY.

were sharing their “tub” with tiny fish, which they misidentified as “minus” [sic]. Actually, the Devils Hole pupfish is a small (adult size <1 inch [2.5 cm] total length) member of Cyprinodontidae, a family known by the common name killifish. Several species that belong to the genus *Cyprinodon* are found exclusively in isolated spring and stream systems of the arid southwestern United States and Mexico. Even by the standards of its congeners, the Devils Hole pupfish is unique in terms of its isolation and limited distribution. Consistent with its name, the Devils Hole pupfish’s native range is limited to the waters of Devils Hole—from the surface to a depth of about 83 feet (25 m), which is the approximate distance that sunlight penetrates the water. Moyle (1976) speculates



that this may be the smallest habitat in the world occupied by an entire vertebrate species. Chances are good that the “49ers” had no idea that the species had subsisted in their makeshift bathtub for thousands of years since the time when its progenitor was stranded there by mechanisms that remain a topic of debate among scientists.

In the late 1960s, the water level in Devils Hole pool began to decline in response to groundwater pumping for irrigation at the nearby Spring Meadows Farm. Concern over the effects on Devils Hole pupfish brought together scientists, resource managers, and interested citizens. This group, which later became the Desert Fishes Council, provided a forum for much of the science that demonstrated the threat of groundwater pumping to the fish. Armed with this information and pressured by broad public support for the pupfish, the U.S. Department of Justice filed for an injunction in federal district court seeking to prevent pumping from those wells that had the greatest effect on water level in Devils Hole. After five years and two appeals, the case reached the U.S. Supreme Court, which in 1976 ruled in favor of the United States, concluding that when the National Park Service (NPS)

acquired Devils Hole it implicitly reserved sufficient water to protect the pupfish and its habitat. Additional legal proceedings followed and pumping was limited to rates that would not lower water level below a reference point—a copper washer bolted to the wall of the cavern.

Following this success, efforts

by The Nature Conservancy and others resulted in the purchase of adjacent lands and the establishment of the Ash Meadows National Wildlife Refuge.

THE STORY CONTINUES

In a simpler world the story of Devils Hole and the pupfish might have ended with these successes. As it stands, however, the outcome has proven to be more complicated and remains subject to uncertainty. Although the initial responses of both water level and pupfish numbers to the restrictions imposed by the court decision were positive, by the late 1980s the pool water level began to drop again. And while pool stage stays above the legally established minimum water level, a slow but steady decrease has continued to the present. A more immediate concern is that the pupfish population has exhibited an overall downward trend from 1996 through the most recent count conducted in January 2005 (fig. 4). That count indicates that the number of pupfish in Devils Hole is lower now than during the period immediately prior to

the Supreme Court decision.

Unlike the situation in the 1970s, reasons for the current declines in water level and pupfish numbers are unclear. Multiple pumping sites in the region and the distances between those sites and Devils Hole make it difficult to discern a relationship between groundwater pumping and

pool-water level, if indeed such a relationship exists. Other factors that could be affecting water level include drought and tectonic activity. In addition, scientists are not certain that the current water level is low enough to adversely affect the pupfish.

In fact, if the information upon which the final court decision was based is correct, the current water level should be adequate to maintain pupfish habitat.

REASONS FOR PUPFISH DECLINE

Scientists who have studied the species over the years have several hypotheses to explain why pupfish numbers appear to be declining; however, none have been adequately tested. Some evidence has caused scientists to speculate that temperatures in Devils Hole may have increased in recent times. Because normal water temperatures in Devils Hole approach thresholds that may be lethal to eggs and early-life stages of the fish, a slight increase could reduce reproductive success (Threlloff and Manning 2003). In addition, people who have worked at Devils Hole for many years believe that substrate on the shallow shelf that underlies the southern section of the pool may contain more fine sediment than it did historically. The shelf is the only area within the pool that is suitable for spawning and is also the location where most primary production occurs (fig. 5). Fine sediments can fill the interstitial spaces of coarser material



Figure 4. Concern about the effects of groundwater pumping on the pupfish habitat at Devils Hole caused scientists, resource managers, and interested citizens to form the Desert Fishes Council. Each year the group conducts population counts of the Devils Hole pupfish.

NPS/JOHN WULLSCHLEGER

Pumping was limited to rates that would not lower water level below a reference point—a copper washer bolted to the wall of the cavern.

Other factors that could be affecting water level include drought and tectonic activity.

Fine sediments can fill the interstitial spaces of coarser material such as gravel and cobble, reducing the movement of water and the concentration of dissolved oxygen.

such as gravel and cobble, reducing the movement of water and the concentration of dissolved oxygen. These conditions, particularly at the warm water

temperatures that occur within Devils Hole, would almost certainly reduce survival rates for eggs and larvae. Moreover, in 2002, blue-green algae proliferated on the surface of the shelf, covering much of the substrate like shrink-wrap. While the causes of this algal bloom remain unknown, biologists suspect that this covering may have prevented pupfish eggs from settling into the gravel, thus exposing them to higher temperatures and increased predation.

REGIONAL PRESSURES

In the region surrounding Devils Hole, groundwater supports agriculture and the rapidly growing urban areas of southern Nevada and California. The NPS Water Resources Division is working to ensure that groundwater withdrawals, which are increasing, do not adversely affect the water level in Devils Hole. Although the underground reservoir from which the water is being withdrawn is vast, annual recharge rates are very low, which is consistent with a desert environment. Thus, recovery of water-level decline from pumping would be very slow, and any damage that might be done to groundwater-dependent resources would likely be long term in nature. While scientists do not know whether the current water level is a factor affecting pupfish, they are clear that if water level continues to decline, the fish ultimately will be adversely affected.

RECENT ACTIVITIES

In response to the observed decline in the number of pupfish, the U.S. Fish and Wildlife Service (USFWS) convened the Ash Meadows Recovery Team. The recovery team held its first meeting in fall 2002 and has been working to ensure the continued survival of the fish. Recent and ongoing activities include development by University of Nevada–Las Vegas researchers of a predictive model that links habitat variables to population dynamics, a

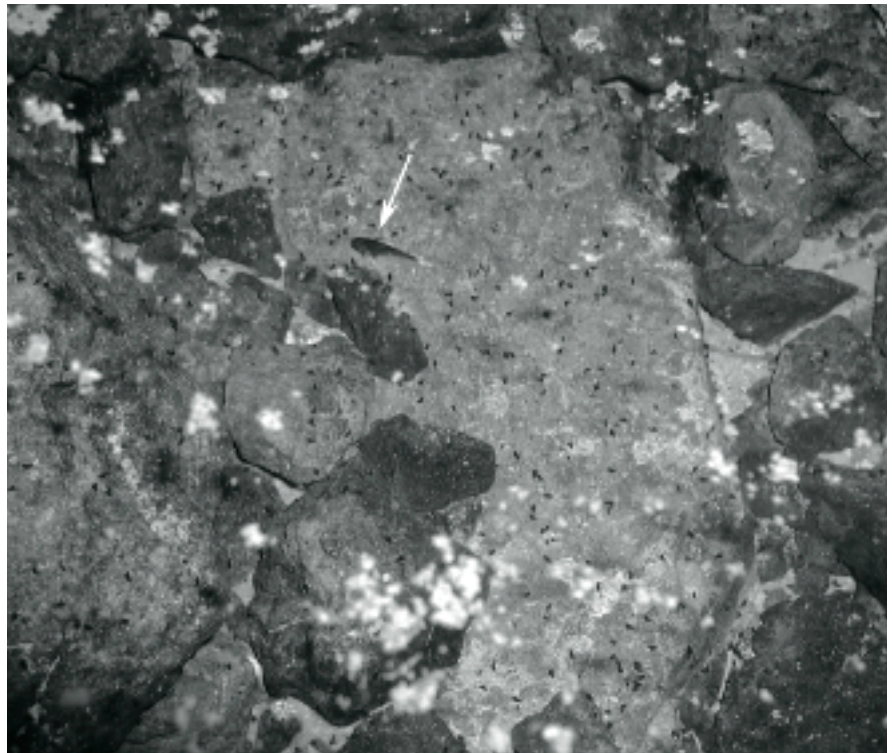


Figure 5. Pupfish forage on the shallow shelf that underlies the southern portion of Devils Hole pool. Conditions on the shelf, which provide a surface for both primary production and spawning, may have deteriorated in recent years because of changes in temperature and increased deposition of fine sediments. A single pupfish appears in the upper center of the photo (arrow). The dark spots on the rocks are mostly a species of snail, one of relatively few invertebrates found in Devils Hole. The white spots are calcium carbonate crystals floating on the surface of the pool. Interestingly these calcium carbonate crystals were the dominant item in pupfish stomachs during food habit studies conducted in the late 1960s and from 1999 to 2000. Because these crystals do not have much food value, investigators believe that they are ingested because of the diatoms on their surface. NPS/JOHN WULLSCHLEGER

Southern Oregon University study of hatching success and larval survival, and an effort to establish a new refuge. Although three refuges exist, pupfish have recently disappeared from one. Conditions in all three refuges have been so different from those in Devils Hole that they subject the fish to different selective pressures, resulting in rapid changes in the appearance and behavior of the fish. The USFWS Ash Meadows National Wildlife Refuge has recently acquired funding under the Southern Nevada Public Lands Management Act (SNPLMA) for the design of a new refuge that will allow closer monitoring by USFWS, NPS, and Nevada Division of Wildlife staffs and will better emulate conditions in Devils Hole. An application for construction funds has been ranked highly in the most recent round of the SNPLMA project selection process. Because of the precarious status of Devils Hole pupfish, establishment of a stable, genetically viable refuge population is critical to the protection of the species.



FUTURE MANAGEMENT

On 11 September 2004 a localized storm deposited an unknown amount of precipitation on Devils Hole and its small but steep watershed. No precipitation occurred at park headquarters or even at the headquarters for Ash Meadows National Wildlife Refuge, a short distance away. As a result, NPS personnel did not visit Devils Hole until several days after the event. Upon arrival they discovered that the security gate and metal frames that were installed for water-level and fish monitoring had interfered with the natural processes of sediment transport and delivery: the gate effectively trapped coarse sediment such as gravels and cobbles; the metal frame, which rests on the shallow shelf, appeared to have interfered with flow across the shelf leading to higher deposition rates of fine sediment. In addition, larval fish sampling equipment, which was temporarily stored inside the gate, was washed into the pool where it resulted in direct mortality of approximately 80 fish.

Actions taken to address the immediate effects of the flood included a February 2005 interagency effort that resulted in the removal of fine sediments and the metal frame that was used to support an access platform. Since then, surveys conducted by Southern Oregon University and the National Park Service have documented the presence of young-of-the-year fish from March through May. Given the absence of successful reproduction following the flood, the presence of these young fish is encouraging. The NPS Water Resources Division has committed funds to a water chemistry study with special reference to DEHP, a plasticizing agent, and the fabrication of a new, less intrusive access platform. DEHP is pervasive in the environment and belongs to a family of chemicals, phthalates, that can reduce reproductive function in aquatic organisms. Recent tests showed elevated levels of this compound compared to tests conducted in 1999.

However, the flood is likely to have more far-reaching effects on the management of Devils Hole: the National Park Service, U.S. Fish and Wildlife Service, and cooperating agencies have become aware of the importance of evaluating the potential adverse effects of actions that are intended to protect the fish and their habitat. Additional actions, which are in various stages of progress, include development of revised protocols for research and management; development of a Devils Hole emergency response plan and contact list; removal or relocation of pool-stage monitoring equipment and development of alternative, less intrusive monitoring methods; installation of transmitters to allow real-time monitoring and more rapid detection of precipitation and seismic events; and relocation of the perimeter fence and security gate to reduce interference with watershed processes.

CONCLUSION

It is humbling for managers and scientists to realize that after more than three decades of research and monitoring, we have been unable to develop a complete understanding of the variables that limit the pupfish in the small and relatively simple aquatic system of Devils Hole. It is equally humbling to recognize that our best efforts to understand and manage Devils Hole have unintended consequences that may themselves prove detrimental. Unfortunately, in light of recent trends and existing and emerging threats, a “hands-off” approach is probably not possible. Providing for the protection of this unique species and its ecosystem is likely to require ongoing research and management programs for the foreseeable future. The challenge for the National Park Service and its partners is to ensure that both research and management are conducted in a manner that minimizes impacts. The still greater challenge that lies ahead is convincing society that preserving Devils Hole and the Devils Hole pupfish are important enough to warrant exercising restraint in the development of groundwater resources in the arid Southwest.

ACKNOWLEDGEMENTS

The authors wish to express their sincere appreciation to the many individuals who have contributed to the protection of Devils Hole and the Devils Hole pupfish. These include personnel from the U.S. Fish and Wildlife Service: Las Vegas Field Station and Ash Meadows National Wildlife Refuge; Nevada Department of Wildlife; U.S. Geological Survey; Death Valley National Park; and faculty and students from Northern Arizona University, Southern Oregon University, and the University of Nevada at Las Vegas. The Desert Fishes Council and members of the NPS Devils Hole dive team also deserve special acknowledgement. Finally, we would like to thank Dr. James Deacon for his contributions to the understanding of the Devils Hole ecosystem and his continued commitment to its preservation.

LITERATURE CITED

- Moyle, P. B. 1976. Inland fishes of California. University of California Press, Berkeley.
- Threlhoff, D. L., and L. Manning. 2003. Thermal environment of the Devils Hole pupfish (*Cyprinodon diabolis*). Death Valley National Park, California: draft NPS report.

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ON THE TRAIL OF AN IMPORTANT ICE AGE FOSSIL DEPOSIT

*Rediscovering the
Port Kennedy Cave
(Middle Pleistocene),
Valley Forge
National Historical Park,
Montgomery County,
Pennsylvania*

By Edward B. Daeschler, Matthew C. Lamanna, and Margaret Carfioli

INTRODUCTION

During the late 1800s a treasure trove of Ice Age fossils was uncovered by limestone quarrying operations at Valley Forge, Pennsylvania. The fossil site, known as Bone Cave or Port Kennedy Cave, was formed in the Irvingtonian stage of the Pleistocene epoch (approximately 750,000 years ago). In a series of important early scientific papers, C. M. Wheatley (1871), E. D. Cope (1871, 1895, 1896, 1899), H. C. Mercer (1895, 1899), and others described plant, insect, turtle, snake, bird, and numerous mammal fossils from the deposit, including several that were new to science. The Port Kennedy Cave is now recognized as one of the most significant Middle Pleistocene vertebrate fossil localities in North America (Kurten and Anderson 1980, Daeschler et al. 1993).

The Port Kennedy Cave was actually a vertical solution cavity in Paleozoic limestone that was briefly opened to the surface, forming a sinkhole in the forested Pleistocene landscape. Plant and rock debris accumulated in the shaft along with the remains of hundreds of animals that were trapped or carried to the edges of this sinkhole by predators (Daeschler 1996). Fauna from the site include giant ground sloth, mastodon, tapir, peccary, skunk, short-faced bear, saber-toothed cat, and many other taxa (fig. 1). Site excavations by Wheatley, Cope, and Mercer in the early 1870s and mid-1890s resulted in the collection of more



Figure 1.
Partial skull of *Smilodon gracilis*
from the Port Kennedy Cave, Valley Forge National
Historical Park, Montgomery County, Pennsylvania. This gracile saber-
toothed cat was first described by paleontologist Edward Drinker Cope
from material collected at the Port Kennedy Cave. The reconstructed
skull length is about 12 inches. TED DAESCHLER, ACADEMY OF NATURAL SCIENCES

than 1,200 fossils, which today are curated in the vertebrate paleontology and paleobotany collections at the Academy of Natural Sciences in Philadelphia.

Although the fossiliferous deposit was never exhausted (see fig. 2, page 32), excavation of the Port Kennedy Cave ceased in 1896 because of groundwater inrush that prevented further work (Mercer 1899, Witte 1957). Then in the early 20th century, the limestone quarry containing the fossil site was filled with asbestos-containing waste materials from the nearby Ehret Magnesia Manufacturing Company. The filling of the quarry and the passage of time have combined to obscure the exact location of this important fossil site, including which of at least three possible quarries holds the site.

At the behest of the Valley Forge National Historical Park, which now encompasses the land containing the fossil deposit, we conducted a study to determine, with as much precision as possible, the location of the Port Kennedy Cave. Rediscovery of this lost site is of great interest to Valley Forge National Historical Park and the scientific community.





FIG. 11.—THE PORT KENNEDY BONE CAVE.

East and west cross-section of the south end of Erwin's quarry (not drawn to scale for the sake of clearness), showing in the shaded parts A, B, C, D the probable original shape, size and relative position of the chasm. The continuous dotted line shows the area of rock and debris, and a portion of the original cave at present removed by the blasting and excavation of limestone at the quarry.

The lined shading of A shows the probable portion of the contents of the chasm removed by Wheatley in 1871.

The lined shading of B shows the part of the contents of the chasm removed by Dr. Dixon and Mr. Rhoads in 1874.

The cross shading of C C shows that part of the contents of the chasm removed by ourselves in 1894, '95, '96.

The dotted shading of D, D, D shows the position of the contents of the chasm still remaining at the site.

The lowest continuous dotted line marking the quarry floor is at the level of the scabbling river. The excessive and increasing influx of water at the point marked by the lower letter C, threatening danger to the quarry, prevented further digging in 1896.

Figure 2. This drawing (from Mercer 1899) illustrates a cross section through the fossiliferous fissure known as Port Kennedy Cave, source of more than 1,200 specimens of Middle Pleistocene fossils. Limestone excavation during the late 1800s exposed the fossil deposit first in 1871 and again in 1894.

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Using the evidence gathered for this project we attempted to answer two questions. First, because several former limestone quarries exist in the search area, we focused on information useful for the identification of the particular quarry containing the Port Kennedy Cave deposit. Once the quarry was tentatively identified, we then attempted to determine the position of the Port Kennedy Cave within the quarry.

RESULTS

The scientific literature on fossils from the Port Kennedy Cave consists of 15 scientific accounts spanning the years 1871 to 1996. The National Park Service included an account of the Port Kennedy Cave in a report on paleontological resources associated with caves in the National Park System (Santucci et al. 2001). Popular accounts and correspondence dealing with the Port Kennedy Cave span a period from

METHODS

Information pertaining to the location of the Port Kennedy Cave was gathered from scientific papers, newspaper and magazine articles, maps, field notes, photographs, and correspondence. We examined material archived at several Pennsylvania institutions, most important of which was the Spruance Library of the Bucks County Historical Society in Doylestown. During visits to the old limestone quarries near the village of Port Kennedy in Valley Forge National Historical Park, we surveyed the landscape, investigated the geology, and examined the size and shape of the principal quarry sites. At that time we were able to compare present-day geological and landscape features with those in several archival photos taken of the Port Kennedy Cave and vicinity during excavation (see fig. 3).

We were able to compare present-day geological and landscape features with those in several archival photos taken of the Port Kennedy Cave and vicinity during [the 19th century] excavation.

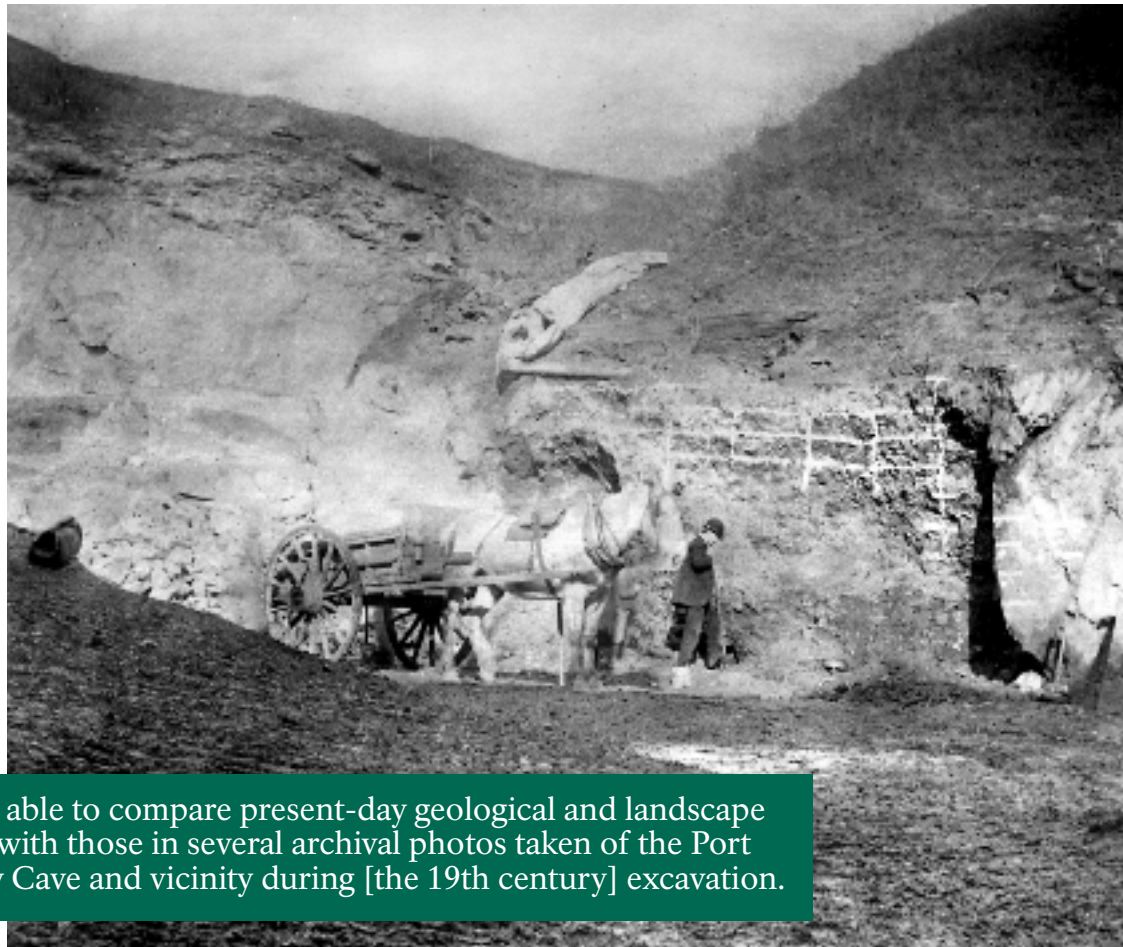


Figure 3. This old photo shows Port Kennedy Cave circa 1894 during excavation of the fossiliferous fissure fill (marked with a grid for recording the location of fossils). Note the upper part of the quarry wall in the left background where bedding of the Triassic shale is visible overlying the limestone.

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1848, when limestone caverns in the area received attention as a scenic wonder, to the present. These sources provide an abundance of general verbal descriptions of the site. For example, Mercer (1899) states that the quarry was located “on the right bank of the Schuylkill [River] two miles below Valley Forge” and “had transformed a gently sloping hillside into an amphitheater several acres in extent.” Hay (1923) determined that it was “about 800 feet away from the [Schuylkill] river and facing the valley of an unnamed streamlet.” These are typical descriptions from published sources and it is clear that many 20th century reports simply restated earlier accounts. Thus, the scientific and popular accounts of the Port Kennedy Cave provide valuable information, although none of it is specific enough to determine the quarry’s location with confidence.

Our search of library archives succeeded in producing more definitive information regarding the location of Port Kennedy Cave. Particularly important were the field notes of Henry Chapman Mercer during the period 1894–1896 when he directed excavations at the site. In his notebook are firsthand descriptions and sketches of the quarry and fossil deposit, including their dimensions. Along with this field notebook from the Spruance Library at the Bucks County Historical Society, we also located several photographs of the Port Kennedy Cave excavations circa 1894.

In our survey of the former limestone quarries near Port Kennedy we were able to match Mercer’s quarry illustration with the shape and dimensions of one of the old quarry sites. We were also able to examine the geological features in the background of the old photos (see fig. 3 for an example) and match them to a unique geological feature in the eastern end of the same quarry. This feature, an unconformity between the Cambrian-period Ledger Formation and the Triassic-period Stockton Formation, is uniquely well exposed in this location. Additionally, early illustrations of the Port Kennedy Cave (see fig. 2 for an example) clearly indicate red shale directly overlying the limestone at the site where the cave was located. Further evidence of the proximity of the site to this geological boundary comes from early accounts of the excavation indicating that the fill within the solution cavity included a large amount of the Triassic rock that had collapsed into the sinkhole. This suggests that the sinkhole was overlain by the shale.

The general descriptions from published accounts of the site, in combination with specific information from Mercer’s notebook and images, allowed us to exclude all but one of the possible quarries from consideration. We

concluded that the aptly named Cave Quarry contains the Port Kennedy Cave because it fits all of the descriptions and uniquely matches the physical and geological setting.

Interestingly, our research confirmed what had been conventional wisdom about the quarry containing the Port Kennedy Cave (Wiswall 1993, McCarthy 1994) but, more importantly, provided documentation and a level of confidence that was previously lacking. With the quarry identified, we then needed to determine the location of the relatively small fossiliferous fissure within the 2-acre (0.8-ha) quarry.

Mercer’s sketches from his field notebook confirmed that the fossil-bearing fissure was toward the easterly wall of the quarry and facing west. Additionally, Mercer’s notes revealed that the Port Kennedy Cave was in shade in the morning but in sunlight in the afternoon, thus located near the eastern margin of the quarry and facing west. Finally, Mercer’s notebook provided distances (in paces) between the fossil deposit and other features, some of

which still exist at the site, allowing us to triangulate the position of the fossil deposit within the quarry. Therefore, we were able to provide a good estimate of its location despite the fact that the unexcavated site is now buried in the floor of the abandoned quarry and covered by 30–40 feet (9–12 m) of fill materials.

With the location of the Port Kennedy Cave within Cave Quarry tentatively determined from the literature, Valley Forge National Historical Park could now make informed decisions relating to this resource. A study utilizing noninvasive technology to confirm the location, depth, and extent of the unexcavated deposit was undertaken in 2004 and, sure enough, the presence of the cave was revealed (see sidebar, page 35)! We now know that the unexcavated deposit is safely preserved in situ beneath the fill of asbestos-containing materials that currently covers it.

The Port Kennedy Cave has local and national significance and beckons exhibition, interpretive programming, and further research. The Academy of Natural Sciences welcomes and encourages the scientific study of its fossil collection from the site.

We concluded that the aptly named Cave Quarry contains the Port Kennedy Cave because it fits all of the descriptions and uniquely matches the physical and geological setting.

Our research confirmed what had been conventional wisdom about the quarry containing the Port Kennedy Cave ... but, more importantly, provided documentation and a level of confidence that was previously lacking.



CONCLUSIONS

Literary detective work involving careful review of scientific and popular accounts of Port Kennedy Cave, as well as correspondence relating to the site, furnished

Information from field notes, photographs, and interpretation of the geological setting provided the crucial evidence.

important clues for this research. Information from field notes, photographs, and interpretation of the geological setting provided the crucial evidence. The combination of these various sources of information allowed us to make a deter-

mination of the location of the Port Kennedy Cave with a high degree of confidence, and our work was confirmed with the use of modern exploratory technology. The management and interpretation of this unique resource within Valley Forge National Historical Park can now be accomplished on the basis of a thoroughly researched library of information.

ACKNOWLEDGEMENTS

First and foremost, we recognize Mr. Brian Lambert, who initiated this project but passed away unexpectedly in November 2003 before the final report was complete. Brian was deeply dedicated to Valley Forge National Historical Park, and the Port Kennedy Cave fascinated him. He provided help and encouragement for our work and was always eager to learn and communicate the story of this interesting chapter in the history of the region. We also would like to acknowledge Ms. B. Lander of the Spruance Library at the Bucks County Historical Society. Mr. A. Shabel of the University of California at Berkeley visited the quarry with us and was part of useful discussions concerning the project. This study was supported by the National Park Service under cooperative agreement CA4560C0046.

LITERATURE CITED

- Cope, E. D. 1871. Preliminary report on the Vertebrata discovered in the Port Kennedy bone cave. *Proceedings of the American Philosophical Society* 12:73–102.
- Cope, E. D. 1895. The fossil Vertebrata from the fissure at Port Kennedy, Pennsylvania. *Proceedings of the Academy of Natural Sciences of Philadelphia* 47:446–450.
- Cope, E. D. 1896. New and little known Mammalia from the Port Kennedy bone deposit. *Proceedings of the Academy of Natural Sciences of Philadelphia* 48:378–394.
- Cope, E. D. 1899. Vertebrate remains from Port Kennedy bone deposit. *Journal of the Academy of Natural Sciences of Philadelphia* 11:193–267.

- Daeschler, E. 1996. Selective mortality of mastodons (*Mammot americanum*) from the Port Kennedy Cave (Pleistocene; Irvingtonian), Montgomery County, Pennsylvania. Pages 83–96 in K. M. Stewart and K. L. Seymour, editors. *Palaeoecology and palaeoenvironments of Late Cenozoic mammals*. University of Toronto Press, Toronto.
- Daeschler, E., E. E. Spamer, and D. C. Parris. 1993. Review and new data on the Port Kennedy local fauna and flora (Late Irvingtonian), Valley Forge National Historical Park, Montgomery County, Pennsylvania. *The Mosasaur* 5:23–41.
- Hay, O. P. 1923. The Pleistocene of North America and its vertebrated [sic] animals from the states east of the Mississippi River and from the Canadian provinces east of longitude 95°. Publication 322. Carnegie Institute of Washington, Washington, D.C.
- Kurten, B., and E. Anderson. 1980. *Pleistocene mammals of North America*. Columbia University Press, New York.
- McCarthy, C. 1994. The case of the disappearing cave. *Lapidary Journal* 47(10):55–56, 58, 60, 126–129.
- Mercer, H. C. 1895. A preliminary account of the re-exploration in 1894 and 1895 of the "Bone Hole," now known as Irwins' Cave, at Port Kennedy, Montgomery County, Pennsylvania. *Proceedings of the Academy of Natural Sciences of Philadelphia* 47:443–446.
- Mercer, H. C. 1899. The Bone Cave at Port Kennedy, Pennsylvania, and its partial excavation in 1894, 1895, and 1896. *Journal of the Academy of Natural Sciences of Philadelphia* 11:269–286.
- Santucci, V. L., J. Kenworthy, and R. Kerbo. 2001. An inventory of paleontological resources associated with National Park Service caves. Technical Report NPS/NRGRD/GRDTR-01/02. National Park Service, Lakewood, Colorado.
- Wheatley, C. M. 1871. Notice of the discovery of a cave in eastern Pennsylvania, containing remains of Post-Pliocene fossils, including those of mastodon, tapir, megalonyx, mylodon, etc. *The American Journal of Science and Arts* 1(4):235–237.
- Wiswall, C. G. 1993. *Valley Forge National Historical Park*. Commonwealth of Pennsylvania, Topographic and Geological Survey, Harrisburg, Pennsylvania.
- Witte, W. H. 1957. The 1896 excavation of Port Kennedy Cave Pennsylvania and other recollections. *Netherworld News* 5(3):4.1–4.4.

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THE LONG-LOST CAVE HAS BEEN FOUND!

By
Jaime Hojdila,
Toni DeMayo,
Sam Baughman,
Tim Bechtel,
and
Margaret Carfioli

After hearing the lore surrounding the Port Kennedy Bone Cave, graduate students from the Masters of Applied Geoscience Program at the University of Pennsylvania (UPenn) teamed up with Enviroscan, Inc., a local geophysics company, and Valley Forge National Historical Park to design and execute a geophysical investigation that could confirm the presence or absence of the cave and its fossils in the quarry indicated by the literature search. Geophysical investigative technology was perfectly suited for this project because the noninvasive nature of the methods avoided the problem of the cave's probable location in one of the park's quarries now filled with hazardous, asbestos-containing materials. Jaime Hojdila, Toni DeMayo, and Sam Baughman of UPenn, and Dr. Tim Bechtel of Enviroscan, developed a three-pronged approach employing the complementary geophysical survey techniques of electrical resistivity, gravity, and magnetics.

We completed surveys during summer and early fall 2004 (fig. 1). The magnetic survey was performed to determine whether rumors of a locomotive that was intentionally crashed into the quarry for the 1915 silent film, "Valley of Lost Hope," were true. The presence of a locomotive at a depth shallower than the Bone Cave could have interfered with attempts to locate the cave using the other two geophysical methods. We measured variations in Earth's naturally occurring magnetic field with the idea that a large, iron-rich object should produce a dramatic magnetic anomaly. The strongest anomalies we found were associated with several pieces of debris visible at the ground surface, and none were of sufficient amplitude or lateral extent to represent the remains of a locomotive at the base of the quarry-waste fill.

The gravity method is based on the phenomenon that lateral changes in subsurface density cause perturbations in Earth's gravity field, with locally higher gravity above denser material, and lower gravity above less dense material. The Port Kennedy Bone Cave is filled with materials of less density (e.g., sand, mud, organic-rich clay) than the surrounding limestone bedrock and was expected to appear as a local low-gravity reading. The resulting gravity map of the survey site illustrated a distinct low-gravity reading (amplitude -0.15 milligals; see anomaly, B in fig. 2, page 36).

The electrical resistivity method uses a pair of electrodes to induce electrical current in the subsurface and another pair of electrodes to measure resulting voltage at various locations. We used the current and voltage readings to calculate the resistivity of the subsurface materials. By adjusting the locations and spacing of the electrodes we calculated resistivity variations for points throughout a three-dimensional block of the subsurface. The scan extends to a depth of 16 meters (52.5 ft) and has a range of resistivity between 1 and 10,000 ohmmeters. The presence of the Port Kennedy Bone

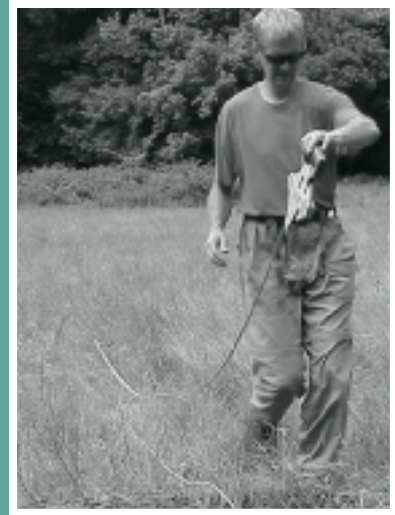


Figure 1. The 1894 photo of the cave site (fig. 3, page 32) shows a surface that is now buried under 30 to 40 feet (9.2 to 12.2 m) of asbestos-containing waste materials. Today the old quarry site surface is covered with grass and trees. Here, Tim Bechtel measures a microgravity and electrical resistivity transect.



Fence diagram plus high-resistivity isosurface and semi-transparent gravity contour overlay

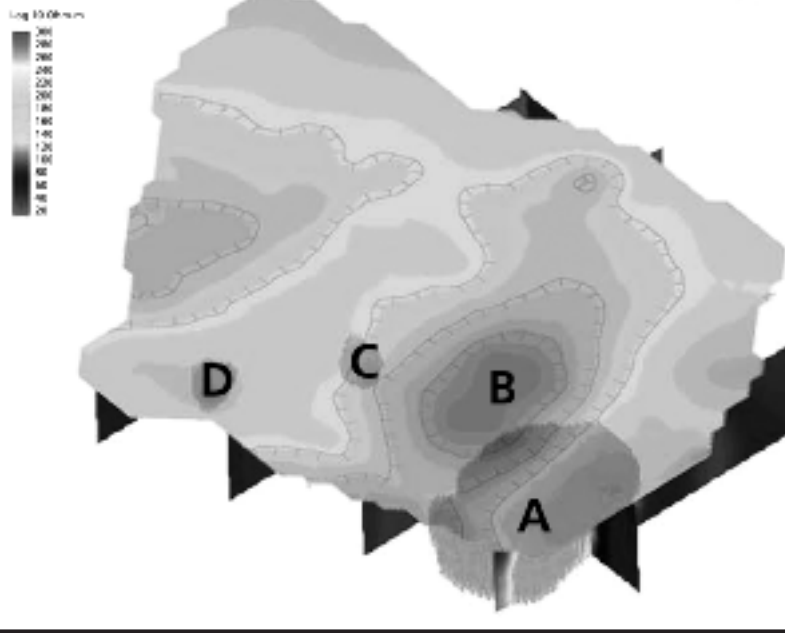


Figure 2. The illustration combines electrical resistivity and gravity measurements to present a three-dimensional view of the Port Kennedy Bone Cave study site. A semi-transparent gravity contour overlays a diagram of the high-resistivity isosurface. The primary feature is the high-resistivity zone (A) roughly beneath (though not perfectly centered on) the main gravity low (B). Two smaller high-resistivity zones (C and D) occur and are possibly consistent with small voids visible in the quarry walls and shown on the 19th century sketches.

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Cave appeared as a zone of anomalous high resistivity (see A in fig. 2).

As a result of this investigation, we are very confident that after being lost for almost 110 years, the Port Kennedy Bone Cave has again been found in 2005.

DEDICATION

This project is dedicated to the memory of Brian Lambert, Natural Resources Manager at Valley Forge National Historical Park 1987–2003. Throughout his years at Valley Forge he dreamed of one day finding the Port Kennedy Bone Cave, and it seems his dream has come true.

ACKNOWLEDGEMENTS

Enviroscan, Inc., donated use of equipment, data processing, and visualizations. The team donated their time and effort throughout this project. The National Park Service provided hazardous waste operations and emergency response training and staff time.

ABOUT THE AUTHORS

Jaime L. Hojdila, Toni DeMayo, and Samuel H. Baughman II were students of the Masters of Applied Geoscience Program at the University of Pennsylvania. Timothy D. Bechtel is adjunct professor at the University of Pennsylvania and vice president of Enviroscan, Inc. Margaret A. Carfioli is the biological science technician at Valley Forge National Historical Park. Inquiries can be directed to Carfioli at 610-783-1041 or margaret_carfioli@nps.gov.





Mapping ecosystems at the landform scale in Washington State

By Jon Riedel and Jeanna Probalá

Resource managers in the North Coast and Cascades Network (fig. 1) have used landform data to identify and understand endangered species habitat, geologic hazards, and cultural resources. Such data are used to create maps, which can help identify the extent of plant and animal communities, model locations of archaeological sites based on “old and stable” landform types, and predict soil distribution in rugged and inaccessible locations. Additionally, park managers may use landform data in the study of natural hazards and for the design of geotechnical projects (e.g., foundations, bridge sites and road cuts, surface and subsurface drainage systems, and remedial landslide stabilization measures). Because landforms directly relate to habitat types, collaboration with the USDA Forest Service has resulted in the identification of the extent of lynx and wolverine habitat by linking landtype, topography, and vegetation.

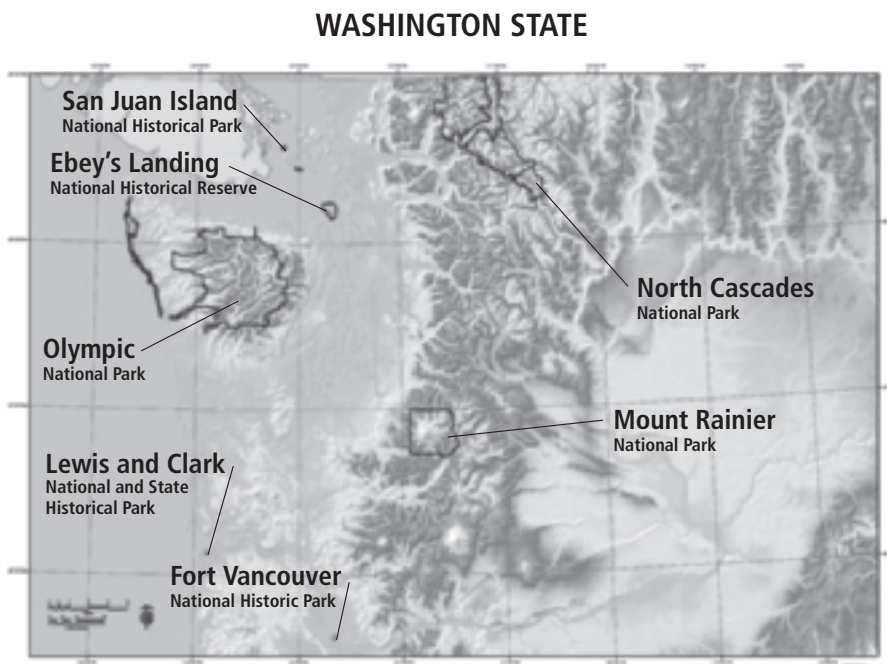
Resource managers ... have used landform data to identify and understand endangered species habitat, geologic hazards, and cultural resources.

Discrete geologic processes such as glaciation, mass movement, and flooding create particular landforms. The link between landforms and geologic processes is the key to their utility for a range of applications. For example, hazardous geologic processes create distinct landforms that are important to recognize for development and public safety.

Using landform data as the cornerstone for developing new approaches for mapping landscapes in Washington State allows resource managers to meet a goal of the Natural Resource Challenge: to complete inventories of soils and surficial geology. In 2003 we began a pilot mapping project at the landform scale (1:24,000) in the lower Elwha River watershed in Olympic National Park. The project’s aim is to provide information on geology-soil-vegetation patterns for future restoration efforts following removal of hydroelectric dams. In addition to mapping terrace, alluvial fan, and floodplain boundaries, we also identified several important moraines deposited by continental glaciers at the end of the last ice age 17,000 year ago, as well as perched deltas and terraces formed in glacial Lake Elwha.

With our collaborators, we have produced landform and surficial geology maps for the Washington Cascades at three different scales: subsection, land-type association, and landform (table 1).

Figure 1. Since 1998 collaborators in landform-scale mapping have completed inventories of several watersheds within the North Coast and Cascades Network, which includes Ebey’s Landing National Historical Reserve, Lewis and Clark National and State Historical Park (incorporating Fort Clatsop National Memorial), Fort Vancouver National Historic Site, North Cascades National Park, Mount Rainier National Park, Olympic National Park, and San Juan Island National Historical Park.



Units of the subsection scale (1:250,000) are determined by climate, bedrock geology, and topography at a regional scale. The landtype-association scale (1:62,500) is based on topography and features created by erosional processes (some landforms are relicts). The landform scale (1:24,000) focuses on depositional landforms created by a range of processes. This multiscaled scheme is a nested system for mapping ecological land units that is known as the “National Hierarchical Framework of Ecological Units” (USDA Forest Service 1993) (table 1). Ecological land units describe the physical and biological processes that occur across the landscape and are used for ecosystem classification and mapping purposes (Davis 2004).

Previous uses of landform mapping

In 1988 staff at North Cascades National Park used the landform-mapping scheme to assess distribution of archaeological sites. This program continued to develop in the early 1990s when a suite of 15 landforms was used to map floodplains and geologic hazards for the general management plan of Lake Chelan National Recreation Area, part of the North Cascades Park Complex. In 1995 the program expanded to meet the needs of North Cascades National Park as a “prototype park” in the national Long-Term Ecological Monitoring Program. To select ecological reference sites, we developed a 23-landform scheme and mapped the Chilliwack and Thunder watersheds, two of three “target watersheds” (table 2).

In 2001, staff at North Cascades National Park and the USDA Forest Service joined forces to map ecological units on all public lands in the North Cascades region. We mapped federal lands at the subsection scale for the Washington Cascades. Examples of the 23-unit scheme include high elevation plateaus and highlands, volcanic cones, and metamorphic cascade hills. We also have cooperatively mapped most of North Cascades National Park and all of Mount Rainier National Park at the landtype-association scale. Landtype-association units include scoured glaciated mountain slopes, glacial valley bottoms, and meltwater canyons. Since 1998 we have modified the 1995 landform-scale scheme to apply it at geologically different parks throughout the North Coast and Cascades Network (fig. 1).

Landform-mapping techniques

Primary tools used to map landforms are topographic maps, DEMs (digital elevation models), digital orthoquad images (digital aerial photos covering a 7.5-minute quadrangle), large-scale stereo air photos, and geologic maps. Initially we use the pattern of contour lines on USGS 7.5-minute topographic maps in conjunction with 1:12,000 color stereo air photos to outline landforms. Though some landforms (e.g., debris avalanches, bedrock benches, and debris cones) are easily recognizable using air

Table 1. National Hierarchical Framework of Ecological Units

Ecological unit	Map scale range
Domain	1:130,000,000 or smaller
Division	1:130,000,000–1:7,500,000
Province	1:15,000,000–1:5,000,000
Section	1:7,500,000–1:3,500,000
Subsection*	1:1,500,000–1:1,250,000
Landtype association*	1:250,000–1:62,500
Landform*	1:24,000

Source: USDA Forest Service (1993).

Note: The National Park Service focuses on mapping at the landform scale.

*Scales at which the USDA Forest Service and National Park Service are mapping in Washington State.

photos and contour lines, other landforms (e.g., terraces and small mass movements) require field identification. Fieldwork generates additional information about terrace heights, floodplain boundaries, and material type. During field investigations, we also complete landslide inventories. After identifying the landforms and drawing the boundaries, we review each area for accuracy and mapping consistency. All boundaries of landforms are then drawn onto UTM- (Universal-Transverse-Mercator-) registered Mylar and a large-format scanner transfers lines into digital format. Using ESRI (Environmental Systems Research Institute) software, scans are edited and polygons (representing landforms) labeled, resulting in a digitized map (fig. 2, page 40).

For an assessment of geologic hazards in 2002 we acquired lidar (light detection and ranging) data for a pilot study of the Tahoma Creek watershed at Mount Rainier National Park, and in 2004 for the lower Stehekin Valley at North Cascades National Park (fig. 3, page 41). Lidar enhances and facilitates mapping because of its ability to penetrate vegetation cover, create three-dimensional bare-earth topographic images, and provide vertical accuracy to approximately 4 inches (10 cm). Because we had previously mapped landforms in these watersheds we used the lidar image to check the accuracy of mapping. We found that our original lines captured most landforms, but that lidar allowed us to adjust boundaries for better precision. Based on these results, we believe future soils, landform, and vegetation mapping projects would benefit from using lidar during the initial stages.

Results and discussion

To date, we have mapped all federal lands along the Cascade crest in Washington State at the subsection scale (table 1). At the landtype-association scale, all of Mount Rainier National Park and 75% of North Cascades National Park are complete. At the landform scale 73% of North Cascades, 15% of Mount Rainier, and 5% of Olympic National Parks are complete. We have mapped,

Table 2. Percentage of watershed by landform type, North Cascades National Park

Landform type (abbreviation)	Watershed (area)				
	Stehekin (209mi ² [542 km ²])	Thunder (116 mi ² [301 km ²])	Chilliwack (84 mi ² [218 km ²])	Bacon (51 mi ² [133 km ²])	Baker (95 mi ² [246 km ²])
Alluvial fan (af)	0.5	0.2	0.1	0.0	0.1
Alluvial fan terrace (ft)	0.2	0.1	0.1	0.1	0.4
Arête (a)	0.5	1.3	1.1	0.5	1.0
Bedrock bench (bb)	1.0	1.0	0.0	0.6	0.3
Debris apron (da)	10.0	9.5	9.8	8.7	5.9
Debris cone (dc)	2.8	2.7	3.8	2.2	2.6
Cirque (c)	6.1	19.3	19.4	12.7	15.9
Floodplain (fp)	1.7	1.9	2.8	1.4	1.5
Horn (h)	0.4	0.6	0.6	0.1	0.2
Little Ice Age moraine (lm)	0.2	0.1	0.3	0.1	0.4
Mass movement–debris avalanche (mm-da)	0.3	2.1	1.5	0.4	0.8
Mass movement–debris torrent (mm-dt)	0.1	0.1	0.0	0.0	0.2
Mass movement–fall/topple (mm-f)	1.4	1.6	0.1	1.0	1.6
Mass movement–slump/creep (mm-s)	0.0	0.0	1.6	0.0	0.0
Other mountain (o) ¹	0.2	0.1	0.0	0.2	0.1
Pass (p)	0.1	0.2	0.2	0.0	0.0
Pleistocene moraine (pm)	0.5	0.2	0.5	0.3	0.1
Ridge (r)	0.7	0.6	2.2	1.1	1.0
River canyon (rc)	1.0	1.3	1.4	0.4	0.8
Terrace (t)	1.0	1.0	1.1	0.9	0.7
Undifferentiated (u) ²	0.1	0.1	0.0	0.0	0.0
Valley bottom (vb)	0.9	0.5	0.2	0.3	0.7
Valley wall (vw)	70.5	55.4	53.1	68.8	65.4

Source: National Park Service (unpublished data 2005).

¹Other mountain (o) is a low-elevation peak that was modified by the Cordilleran Ice Sheet.

²Undifferentiated (u) is a landform of unique expression that staff cannot explain and does not fit within other units in the scheme.

but not yet finalized, areas in San Juan Island National Historical Park and Ebey’s Landing National Historical

We have mapped all federal lands along the Cascade crest in Washington State at the subsection scale.

Reserve. At the 2001 George Wright Society biennial conference, we presented mapping at the three scales. We also showed our results of mapping specifically at the landform scale within North Cascades National Park at

the 2003 Geological Society of America annual meeting (Riedel et al. 2003).

Using landform mapping at North Cascades National Park, we estimate that landslides cover an area of about 2.4% of each watershed mapped to date; combined with debris cones and debris aprons they cover about 11% of the park. The majority of the park is classified as cliff and valley wall, which underscores the active nature of geology in this region.

Information on landscape stability provides a means for site selection of long-term ecological monitoring reference



sites and facility location. We created a landslide database to accompany landform maps with data collected on 18 characteristics of each landslide, including age (if known), activity, bedrock geology, volume, material type, and impact to streams. These characteristics describe the stability of a slope and the impacts to streams. They also aid in cost and risk management decisions of trail, campground, and bridge placement.

At North Cascades National Park, we identified 222 landslides in the Baker River valley and classified 33 as mass movement–debris avalanches (table 2). A debris avalanche is the largest of four landslide types mapped and these deposits are particularly significant because of their size, potential to block streams, and ability to transport massive amounts of large woody debris and sediment. Debris avalanches displace millions of cubic meters of debris. More than half of the avalanches mapped in the Baker River valley either delivered sediment to a stream or blocked it entirely. Three of the largest debris avalanches in the Thunder Creek watershed have periodically blocked Fisher Creek (fig. 2).

At the landform scale at North Cascades National Park, results indicate that floodplains and associated riparian and aquatic habitats are found in only 2% to 3% of the watersheds. Knowing the location and extent of the limited riparian and aquatic habitat has important implications for recovery of chinook salmon (*Oncorhynchus tshawytscha*) and bull trout (*Salvelinus confluentus*), two threatened and endangered aquatic species.

Stable, relatively old surfaces such as terraces and bedrock benches occur in only 2% to 6% of the mapped watersheds at North Cascades National Park. Previously linked landform-archaeological surveys in the park have shown a close relationship between archaeological site density and landform type (age). That is, the oldest surfaces in this rugged and remote area correspond to the most extensive human occupation during the past 10,000 years.

A major gap in our natural resource inventories is information about soils.

Needs and developments

A major gap in our natural resource inventories is information about soils. Soils data from the North Coast and Cascades Network are limited to an outdated soil survey for Ebey’s Landing National Historical Reserve and a survey, in progress, at San Juan Island National Historical Park. Using “traditional” methodologies, relative inaccessibility and estimated high costs have precluded extensive

soil surveys in North Cascades, Olympic, and Mount Rainier National Parks. Because parent material, time (age), and relief are three of five soil-forming factors, digital landform maps are the cornerstone of new approaches

to mapping soils in remote, rugged landscapes. Understanding this link between soils and landforms allowed us to develop a pilot project with Washington State University that used our landform maps of Thunder Creek watershed as a primary data layer in development of a soils model.

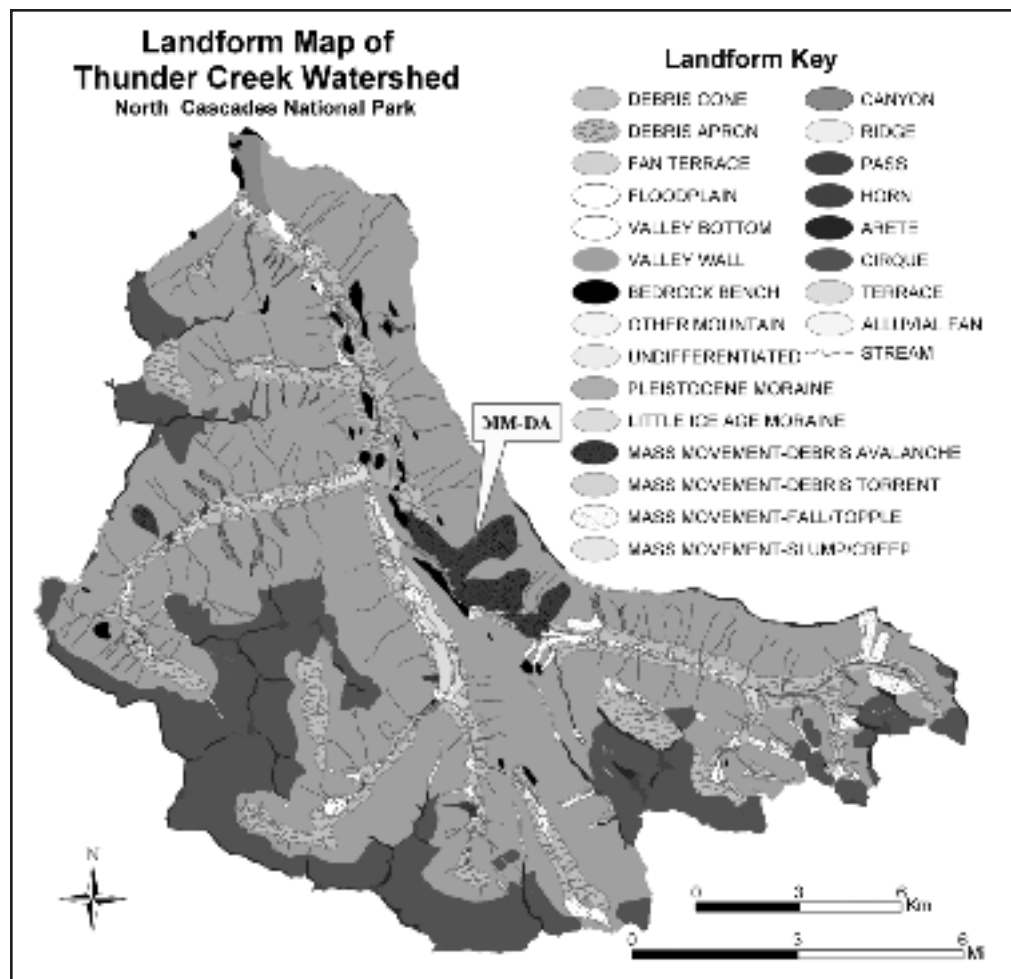


Figure 2. Landform maps at the scale of 1:24,000 provide the resolution necessary to address key resource management issues. Landslides, particularly the largest of four types called debris avalanches, are of management concern because of their size, potential to block streams, and ability to transport massive amounts of debris. The label “MM-DA” highlights one of the largest debris avalanches in the Thunder Creek watershed, covering an area of about 0.8 square mile (2 km²).

SOURCE: NATIONAL PARK SERVICE (UNPUBLISHED DATA 2003).

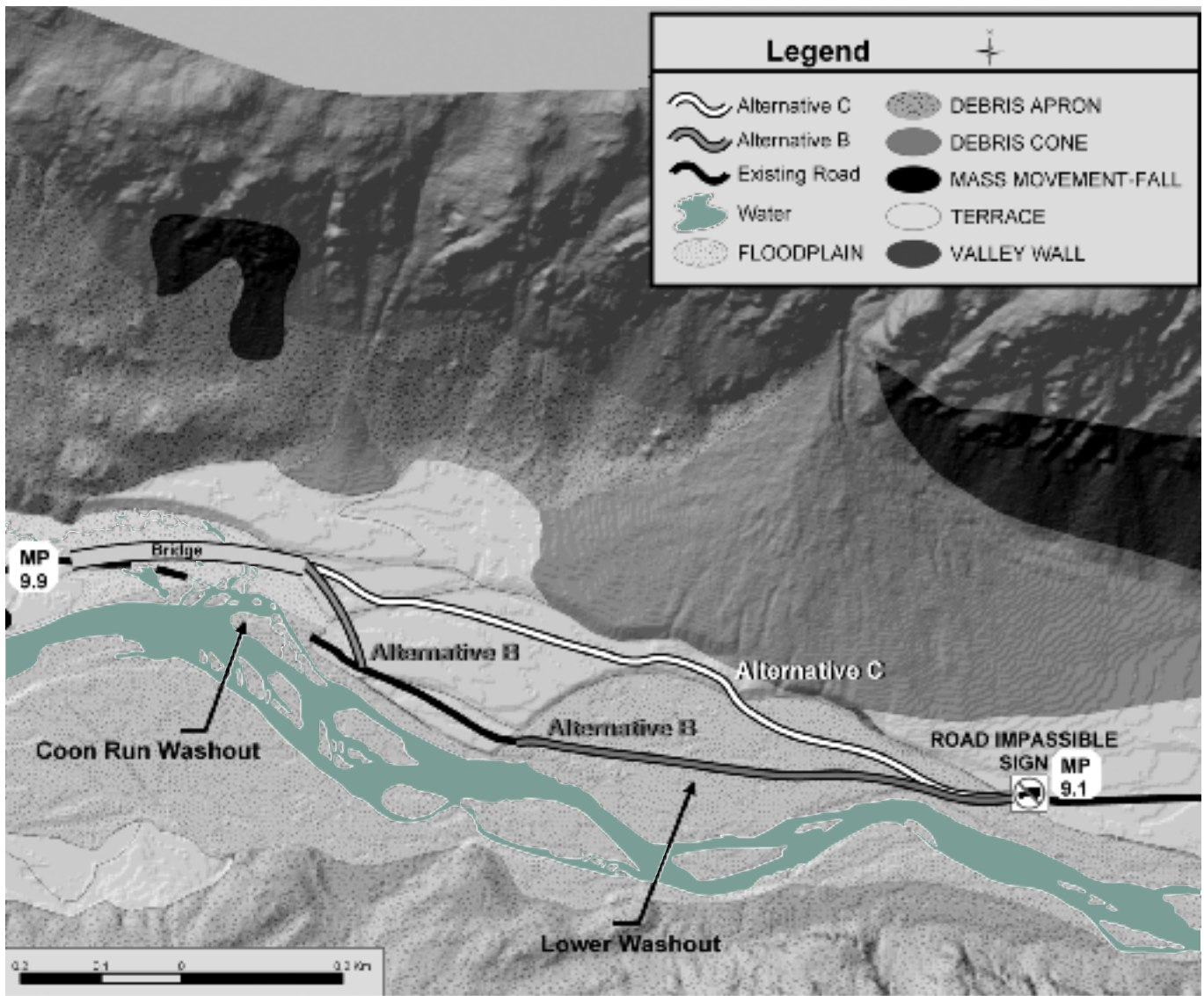


Figure 3 (map). In October 2003 a heavy rain-on-snow event flooded many rivers across western Washington. At North Cascades National Park, the floods washed out two sections of the Stehekin Valley road. Resource managers used landform maps and lidar to assist in developing road replacement alternatives. Alternative B suggests partially rebuilding the road on a floodplain; alternative C uses terraces adjacent to the floodplain; both use a bridge spanning the most hazardous spot.

SOURCE: NORTH CASCADES NATIONAL PARK (UNPUBLISHED DATA 2005).

Soil Order Distribution Among Landforms

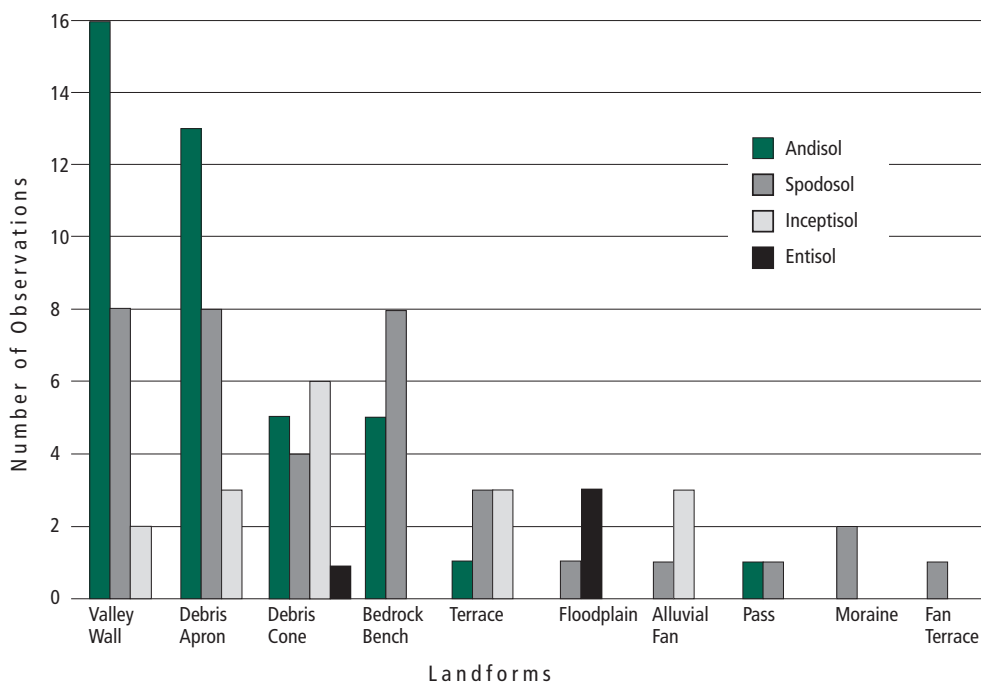


Figure 4 (graph). Landform data show a strong correlation between landform type and soil order. For example, in the Thunder Creek watershed, andisols (soils formed in volcanic ash) are associated with landforms such as debris aprons where ash accumulates. Spodosols (acid soils with a subsurface accumulation of metal-humus complexes) are associated with older landforms such as moraines and terraces. Inceptisols (soils with weakly developed subsurface horizons) and entisols (soils with little or no morphological development) are found on recent floodplain and landslide deposits.

SOURCE: CRYSTAL BRIGGS, WASHINGTON STATE UNIVERSITY (UNPUBLISHED DATA 2003).



Linking soils information to landforms is a cooperative effort among North Cascades National Park, the Natural Resource Conservation Service state mapping program, USDA Forest Service, Washington State University, and the NPS Soils Program.

Digital landform maps are the cornerstone of new approaches to mapping soils in remote, rugged landscapes.

A digital soils model using landform data from Thunder Creek watershed shows a strong correlation between landform type and soil order (fig. 4).

Encouraged by these

results, we are currently using landform maps to develop soil models for the remainder of North Cascades National Park. We will continue to develop this approach with our partners to obtain soil resource inventories for all units of the National Park System in Washington State.

Future work

In addition to soils mapping, our immediate efforts will focus on two areas. First, we will complete landtype-association scale mapping of North Cascades and Olympic National Parks. Second, we will complete landform-scale mapping for all of North Cascades and Mount Rainier National Parks, and the Elwha River valley at Olympic National Park. We will continue to use lidar, where available, to assist with mapping of new areas and to check previously mapped watersheds. Also, in order to standardize data collection within the network and to help assist future researchers, we are developing a landform-mapping protocol and a report for each large watershed.

References

Davis, C., 2004. Landtype associations of north-central Washington. USDA Forest Service, Wenatchee, Washington.

Riedel, J., M. Davis, and J. Probala. 2003. Surficial geology mapping of North Cascades National Park. Geological Society of America Abstracts with Programs 35(6):75.

USDA Forest Service. 1993. National hierarchical framework of ecological units. U.S. Department of Agriculture, Washington, D.C.

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“Notes from Abroad” continued from page 25

broader scale, nonprofit groups like the Yellowstone Yukon Conservation Initiative are promoting the local establishment of such wildlife-movement corridors to connect core habitat areas along the entire length of the Rocky Mountain cordillera.

Selected references

Clevenger, A. P., B. Chruszcz, and K. Gunson. 2001. Drainage culverts as habitat linkages and factors affecting passage by mammals. *Journal of Applied Ecology* 38:1340–1349.

Clevenger, A. P., B. Chruszcz, and K. Gunson. 2001. Effectiveness of highway mitigation fencing at reducing wildlife-vehicle collisions. *Wildlife Society Bulletin* 29:646–653.

Clevenger, A. P., and T. McGuire. 2001. Research and monitoring the effectiveness of Trans-Canada Highway mitigation measures in Banff National Park, Alberta. Proceedings of the Transportation Association of Canada Annual Conference, 17–20 September 2001, Halifax, Nova Scotia.

Clevenger, A. P., and N. Waltho. 2000. Factors influencing the effectiveness of wildlife underpasses in Banff National Park, Alberta, Canada. *Conservation Biology* 14:47–56.

Clevenger, A. P., J. Wierzchowski, B. Chruszcz, and K. Gunson. 2002. GIS-generated expert-based models for identifying wildlife habitat linkages and mitigation passage planning. *Conservation Biology* 16:503–514.

Forman, R. T. T., J. Bissonette, A. Clevenger, C. Cutshall, V. Dale, L. Fahrig, E. Goldman, K. Heanue, J. Jones, D. Sperling, F. Swanson, T. Turrentine, and T. Winter. 2002. *Road ecology: science and solutions*. Island Press, Washington, D.C.

Gloyne, C. C., and A. P. Clevenger. 2001. Cougar use of wildlife crossing structures on the Trans-Canada Highway in Banff National Park, Alberta. *Wildlife Biology* 7:117–124.

Little, S. J., R. G. Harcourt, and A. P. Clevenger. 2002. Do wildlife passages act as prey-traps? *Biological Conservation* 107:135–145.

Parks Canada. 1996–2003. Effects of the Trans-Canada Highway on wildlife in Bow Valley: a research, monitoring, and adaptive mitigation program. Parks Canada, Banff National Park, Alberta, Canada.

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FIRE IN THE PINES

A 341-year fire and human history at Big Spring Pines Natural Area, Ozark National Scenic Riverways

By Michael Stambaugh, Richard Guyette, and Charles Putnam

The relationship between humans and fire bears directly upon National Park Service policy and park management. The National Park Service strives to restore natural processes and conditions to areas disturbed by human activities such as fire suppression (National Park Service 2001). Information about fire history and historical and current vegetation conditions and processes helps land managers identify desired future conditions for natural communities. This information also helps to justify and set targets for wildland fire practices.

In the Ozark Highlands of Missouri, fire scars on shortleaf pine (*Pinus echinata* Mill.) tree rings date to the 16th century and possibly earlier. These scars reveal one of the world's densest fire-history networks surrounding the Ozark National Scenic Riverways. In general, fires occurred throughout the region every 8–15 years from the 16th to 19th centuries. With the immigration of eastern Native American tribes and European settlers into the Ozarks, fire frequency increased during the late 18th and early 19th centuries. Fires occurred frequently during the mid to late 19th and early 20th centuries, but extensive burning ended abruptly about 1930, and tree density subsequently increased (Schroeder 1983, Ladd 1991, Nelson 1997).

During this study, we documented the history of fire at Big Spring Pines Natural Area by analyzing fire scars on tree rings. Our study objectives were to (1) create a fire history from pine remnants, (2) relate the fire record to human population, and (3) identify implications for fire management.

STUDY SITE

Our study area consists of approximately 200 acres (80 ha) including the Big Spring Pines Natural Area (fig. 1).

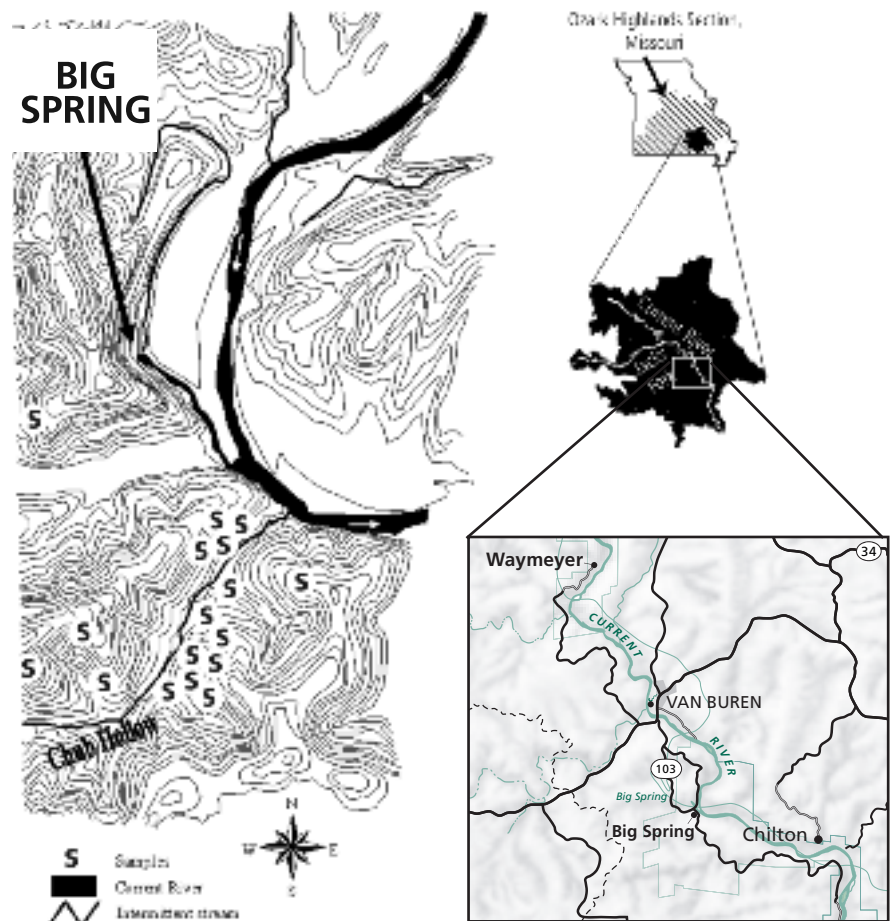


Figure 1. The study area consists of approximately 200 acres (80 ha) that includes the Big Spring Pines Natural Area. This map of the study area shows topography, the location of Big Spring, and the Current River. The letter "S" indicates locations of sample trees with their sample number. Insets are (top) state of Missouri showing location of Ozark Highlands subsection (Nigh and Schroeder 2002), (middle) Current River Hills subsection, and (bottom) the landscape of the Big Spring vicinity. MISSOURI TREE-RING LABORATORY



The natural area is a 345-acre (140-ha) old-growth pine-oak forest that lies adjacent to the third largest spring in North America. It is noteworthy for 200-year-old shortleaf pines, lack of pine regeneration, floral diversity, and a topographically rough landscape with many valleys and ridges.

Shortleaf pine and oaks are the most important species in the overstory. Because of fire suppression, shortleaf pine is nearly absent in the understory and regeneration layers. Shortleaf pine has characteristics adapted for fire disturbances: seeds that germinate on sites with little soil and litter, seedlings' ability to resprout following top-kill, and sapling-sized trees having high resistance to death following burning. Currently, the most frequent natural disturbance is canopy gaps created from dead overstory trees. However, in similar Ozark shortleaf pine forests, canopy gaps are ineffective for promoting shortleaf pine (Stambaugh et al. 2002).

FIELD SAMPLING AND TREE-RING DATING

Fire history projects like this cost between \$15,000 and \$25,000. Fieldwork typically requires one week of two to four persons. Locating and collecting samples is often time intensive. The process of project proposal, sample cataloging, fieldwork, sample preparation, tree-ring measurement and dating, fire scar identification and analysis, and report writing typically occurs over a one-year period. Actual time on this study was less than typical because the study was part of a larger parkwide research project in which certain efforts could be combined.

In 2001 we collected cross sections from 23 shortleaf pine stumps and dead standing trees (fig. 2) on all aspects and elevations

We applied dendrochronology ... to precisely date annual growth increments.

including alluvial terraces of the Current River. We applied dendrochronology, a method that uses tree-ring variation caused by weather, to precisely date annual growth increments (Stokes and Smiley 1968, Guyette and Cutter 1991). We sanded cross-sections to a high polish (fig. 3), measured tree rings to an accuracy of 0.00394 inch (0.01 mm), and imported measurements into COFECHA (Grissino-Mayer 2001), a program that checks the accuracy of dating and measurements. We identified fire scars by features of callus tissue, cambial death, and charcoal, and designated fire scar years as the first year of growth in response to the fire injury. We used FHX2 software (Grissino-Mayer 1995) to develop a fire

chronology and descriptive statistics for both the composite and individual tree mean fire intervals. We grouped fire intervals into corresponding cultural periods: Native American (before 1780), Native American and European transition (1780 to 1850), agriculture (1851 to 1930), and fire suppression (after 1930) (fig. 4, page 46).

COMPOSITE FIRE CHRONOLOGY

Shortleaf pine cross sections yielded a continuous 341-year-long tree-ring record from 1634 to 1974. No fires have occurred at the site from 1974 to present. Of the original 23 cross sections, we selected 16 to sample based on wood quality, presence of fire scars, and number of tree rings; seven samples were not used because of dating difficulty or lack of fire scars. We dated a total of 193 fire

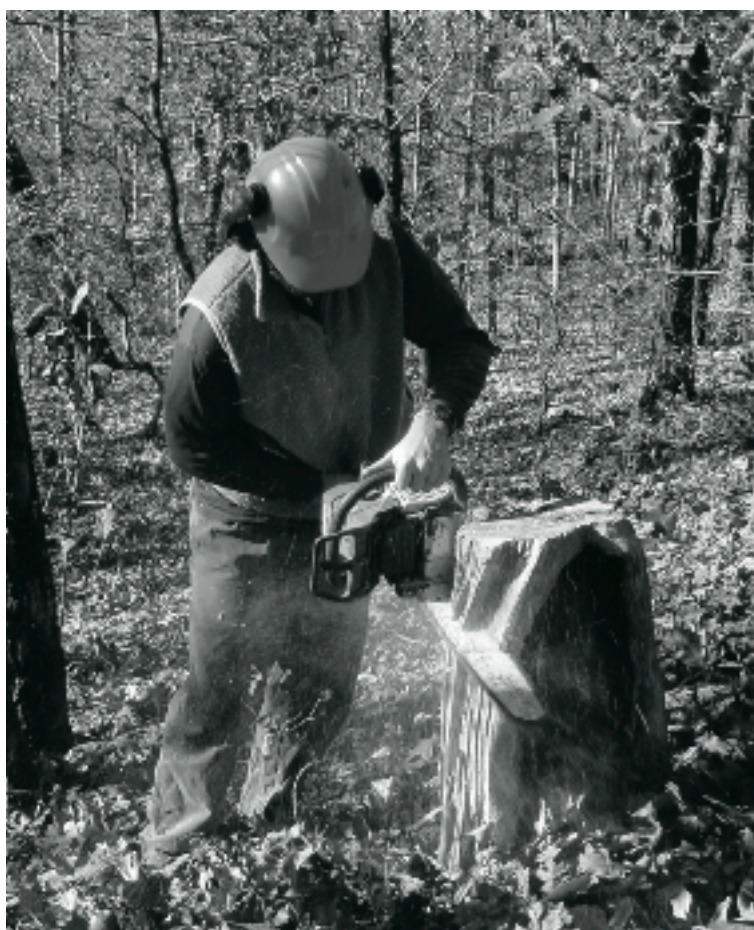


Figure 2. Stumps of shortleaf pine trees that were cut around the end of the 19th century still persist throughout much of the Ozark Highlands region. Although the tree is gone, the resinous stump in this photo has persisted for a century following cutting. Important historical information about past climate and fire, often dating to the 16th century, exists within remnant stumps. The blackened oval-shaped surface on the stump is the charcoal created from past fires. Here, a worker begins to cut a cross section of a stump that will be polished to reveal cellular detail of annual rings and fire scars. MISSOURI TREE-RING LABORATORY

scars from the 16 sample trees. The mean fire interval was 2.8 years and ranged from 1 to 58 years for the entire record (table 1). Variation in mean fire intervals corresponded to cultural and land use periods. Nearly annual burning occurred at the site from 1813 to 1888. Conversely, the longest intervals without fire were from 1668 to 1726 and from 1932 to 1974. The percentage of trees scarred provides an estimate for the size or intensity of a fire event. In 14 different years of the fire record, more than 30% of the trees sampled were scarred. The highest percentage of trees scarred in any single year was 57% (1877) and six other years had more than 40% trees scarred. The average percentage of trees scarred for all years with fires was 18%. More than 90% of the scars resulted from fire occurring during the dormant season (i.e., September through March).

Table 1. Summary statistics of fire record at Big Spring Pines Natural Area

Record of period	Interval (n)	Mean fire interval (±SD)	Range (years)
Entire period	95	2.8 (±6.5)	1– 58
Native American (before 1780)	5	22.4 (±21.5)	5– 58
Euro-American settlement (1780–1850)	38	1.8 (±1.2)	1– 6
Agriculture (1851–1930)	50	1.56 (±1.0)	1– 6
Fire suppression (after 1930)	–	70 ^a	2 ^b – 75

Note: Periods of record were delineated by cultural and land use changes in the region.
^aMean fire interval is based on the last fire recorded at the site and information of no subsequent fires occurring at the site between 1974 and 2002.
^bTwo-year interval is a result of 1932 fire and is not representative of the larger fire suppression period.

FIRE INTERVALS FOR INDIVIDUAL TREES

Fire intervals ranged from 1 to 87 years with a mean of 6.2 years (±8.0 SD). The median fire interval was 5.0 years (table 1). The average number of years from all initial scars to the second scar was 8.8 years and ranged from 2 to 21 years. One tree (#8), located approximately 328 feet (100 m) from the edge of the Current River and less than 16 feet (5 m) above its bank-full water level (see fig. 1), had 40 fire scars between 1780 and 1925.

DISCUSSION

During this study, we found that fires were most commonly low intensity and rarely scorched tree crowns. We found an association between human population density and fire frequency, which suggests that fires were of anthropogenic origin at least as early as the 17th century (Guyette et al. 2003a). During the 20th century, humans have caused nearly all fires in the state (Missouri Rural Fire Departments, unpublished data, 2003).

The inside ring dates, or regeneration dates, of our sample trees and the current size class structure of pines at Big Spring Pines Natural Area show a continual regeneration of pine from the 17th to 19th centuries despite a variable burning frequency of 1 to 58 years (table 1). Applying this

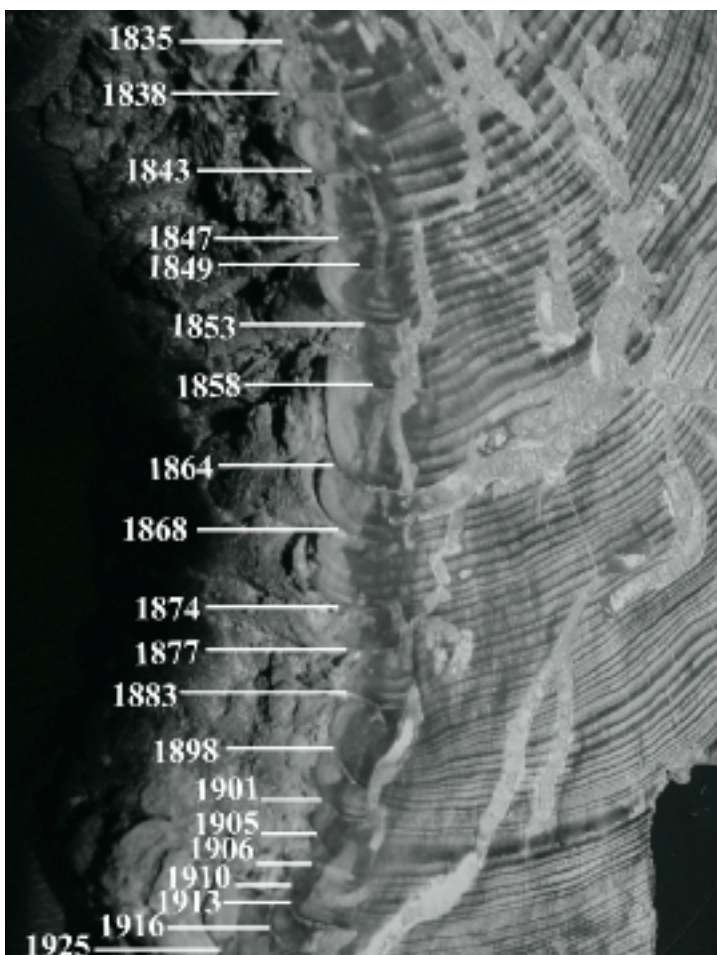


Figure 3. From the 1830s to the 1920s, fire disturbance was common throughout much of the Missouri Ozarks. A polished cross section of shortleaf pine tree rings from Big Spring Pines Natural Area shows curling scar tissue that represents the year of response to injury from fire. Lines and corresponding calendar years point to the scar tissue. MISSOURI TREE-RING LABORATORY



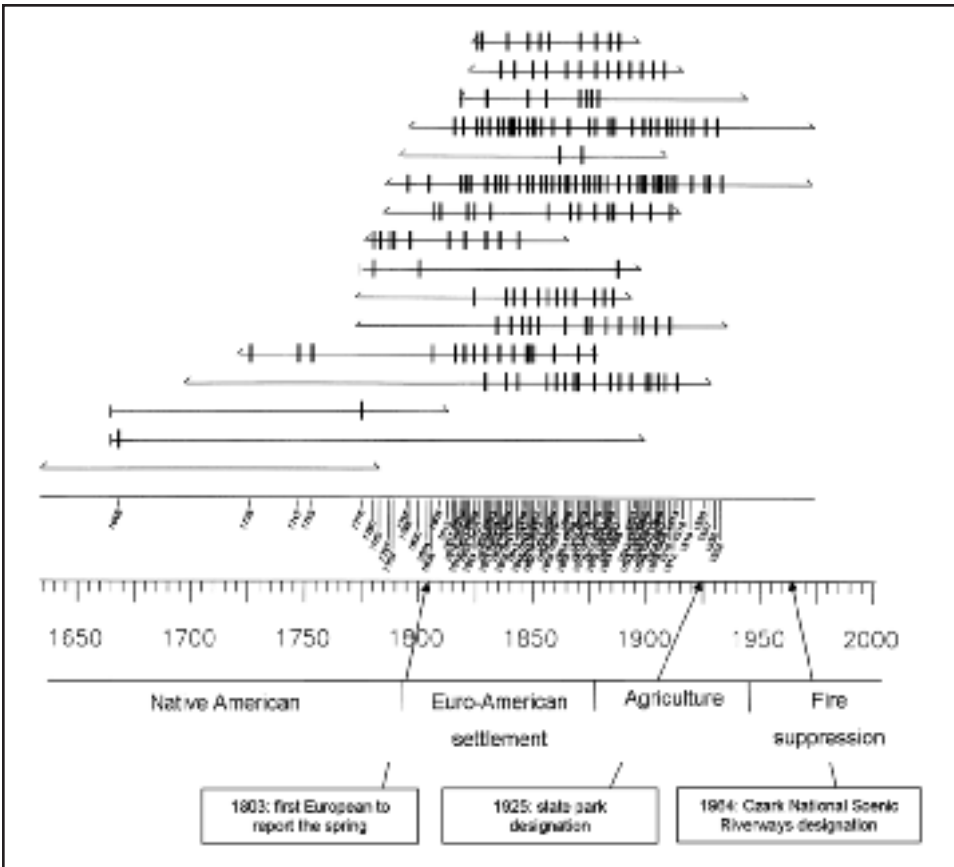


Figure 4. Investigators analyzed 16 trees, which revealed 193 fire scars and 96 years with fire. Calendar years are shown on the x-axis with associated cultural periods and significant historical events denoted beneath. Horizontal lines represent the period of record for each sample tree; bold vertical bars represent fire scar years on the tree. Pith dates (the years of tree regeneration) are represented by short, thin vertical lines at the left end of the horizontal lines, while inside ring dates (first tree ring, pith absent) are represented by diagonal lines (FHX2 software, Grissino-Mayer 1995). Cultural periods are based on population density estimates in Guyette et al. 2002.

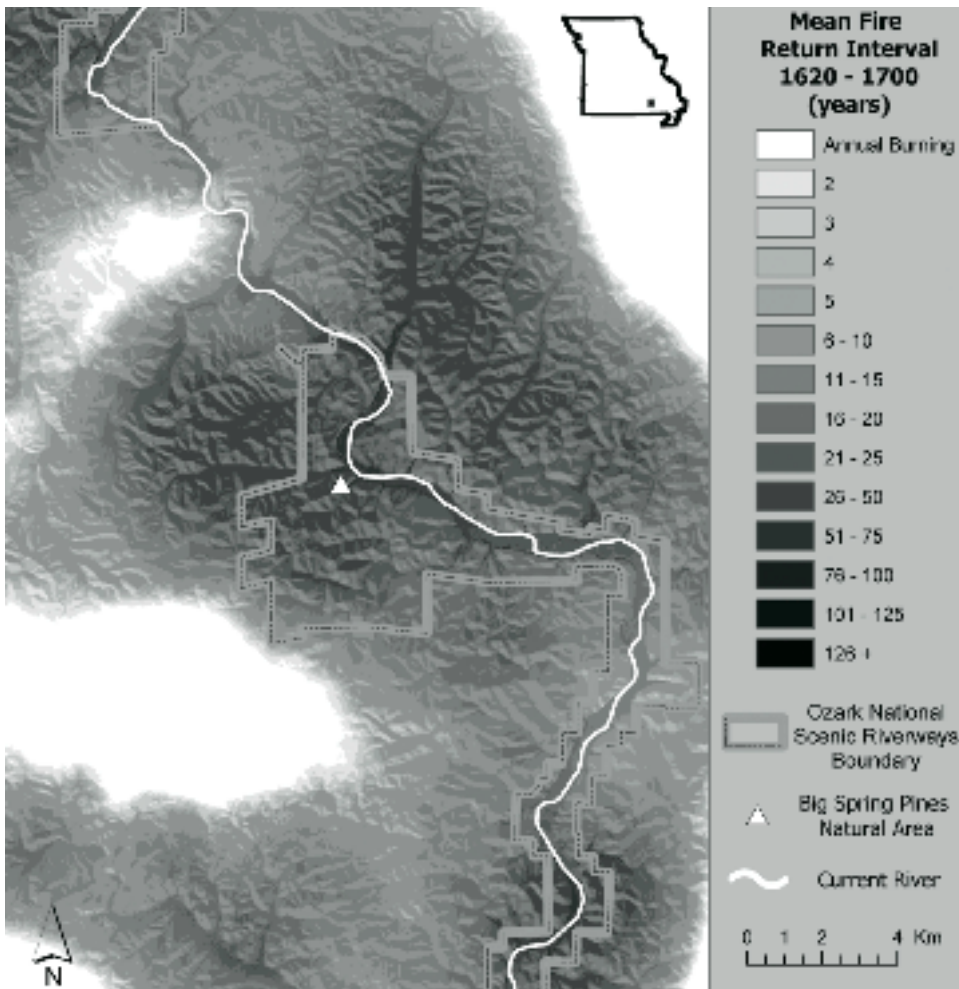


Figure 5. Investigators use models that combine topography (i.e., digital elevation models), fuels, and human population density of fire history sites to estimate mean fire intervals across a landscape. Estimates of mean fire intervals for the period 1620 to 1700 in the vicinity of the Big Spring Pines Natural Area are illustrated on this map. The map is based on calibrated equations that explain 46% of the variance in the mean fire intervals of 35 fire history sites (Guyette et al. 2003b). White areas of the map are topographically smooth surfaces (i.e., few valleys and ridges) of the Ozark Plateau that encompass the more deeply dissected vicinity of the Big Spring Pines Natural Area. DATA SOURCE: MISSOURI TREE-RING LABORATORY

A continual regeneration of pine from the 17th to 19th centuries ... suggests that incorporating variability in the number of years between burns would best mimic the presettlement fire regime.

finding to management suggests that incorporating variability in the number of years between burns would best mimic the presettlement fire regime. Longer

intervals likely allowed pines to attain sizes large enough to survive subsequent fires. Restoration of a variable fire regime might be achieved by burning every 1 to 3 years until hardwood vegetation is reduced and pine significantly regenerates, followed by a lengthened and variable burning frequency (e.g., 10 to 15 years) to ensure the survival of the newly established cohort into the sapling size class.

The long-term variability in fire frequency, human population density, and cultural practices reveals the historical importance of human influence on vegetation not only at the Big Spring Pines Natural Area but, by extension, in the entire region of Ozark National Scenic Riverways. The high density of fire history sites around this unit of the National Park System allowed us to describe the spatial and temporal variability in the fire regime. Broader scale studies that combine data on topography (i.e., digital elevation models), fuels, and human population density have provided the means for modeling mean fire return intervals for the entire park (Guyette et al. 2003b). These models, empirically derived from fire history sites such as the natural area, are used to generate maps that assign estimates of mean fire intervals to all locations on a landscape for a given time period (Guyette et al. 2003b) (fig. 5).

Reconstructed fire histories provide information that land managers need to justify and set targets for wildland fire practices such as Fire Regime Condition Classes (FRCCs). To identify desired future conditions for park natural communities, managers must identify historical and current vegetation conditions and processes. Fire history information quantifies the fire disturbance process and its characteristics in the park environment, and can provide supporting evidence for historical vegetative conditions and the influence of humans on those conditions.

ACKNOWLEDGMENTS

We thank the National Park Service, Ozark National Scenic Riverways, for permission to conduct research at Big Spring. Additional thanks go to Victoria Grant for her assistance in providing GIS data relative to this study. National Park Service Fire Pro research funded this study.

REFERENCES

- Grissino-Mayer, H. D. 1995. Tree-ring reconstructions of climate and fire history at El Malpais National Monument, New Mexico. Ph.D. thesis. University of Arizona, Tucson.
- Grissino-Mayer, H. D. 2001. Evaluating crossdating accuracy: A manual and tutorial for the computer program COFECHA. *Tree-Ring Research* 57(2):205–221.
- Guyette, R. P., and B. E. Cutter. 1991. Tree-ring analysis of fire history of a post oak savanna in the Missouri Ozarks. *Natural Areas Journal* 11:93–9.
- Guyette, R. P., R. Muzika, and D. C. Dey. 2002. Dynamics of an anthropogenic fire regime. *Ecosystems* 5:472–486.
- Guyette, R. P., D. C. Dey, and M. C. Stambaugh. 2003a. Fire and human history of a barren-forest mosaic in southern Indiana. *American Midland Naturalist* 149:21–34.
- Guyette, R. P., M. C. Stambaugh, and D. C. Dey. 2003b. Riparian fire history in the Ozark National Scenic Riverways. USDI NPS PO #6640010030. Ozark National Scenic Riverways, Van Buren, Missouri.
- Ladd, D. 1991. Reexamination of the role of fire in Missouri oak woodlands. Pages 67–80 in R. L. Hay, F.W. Woods, and H. DeSelm, editors. *Proceedings of the 6th Central Hardwood Forest Conference*, 24–27 February, Knoxville, Tennessee.
- National Park Service. 2001. Management policies 2001. U.S. Department of the Interior, National Park Service, Washington, D.C.
- Nelson, J. C. 1997. Presettlement vegetation patterns along the 5th Principal Meridian, Missouri Territory, 1815. *American Midland Naturalist* 137:79–94.
- Nigh, T. A., and W. A. Schroeder. 2002. Atlas of Missouri Ecoregions. Missouri Department of Conservation, Jefferson City, Missouri.
- Schroeder, W. A. 1983. Presettlement prairie of Missouri. *Natural History Series 2*. Missouri Department of Conservation, Jefferson City.
- Stambaugh, M. C., R. M. Muzika, and R. P. Guyette. 2002. Disturbance characteristics and overstory composition of an old-growth shortleaf pine (*Pinus echinata* Mill.) forest in the Ozark Highlands, Missouri, USA. *Natural Areas Journal* 22:108–119.
- Stokes, M. A., and T. L. Smiley. 1968. Introduction to tree-ring dating. University of Chicago Press, Illinois.

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Lava Beds National Monument:

A stronghold for Townsend's big-eared bats

By Kelly Fuhrmann

Lava Beds National Monument in northern California is geologically and ecologically remarkable because of its great variety of “textbook” volcanic formations. It is situated at the northeast flank of the Medicine Lake Volcano, at the junction of the Sierra-Klamath, Cascade, and Great Basin geological provinces. Its rugged, semi-arid, high-elevation volcanic terrain and associated ecosystems support more than 560 species of plants and animals, including 14 species of bats (see related article on page 52 about monitoring Mexican free-tailed bats). The numerous lava caves within the park provide habitat for bats, notably the Townsend's big-eared bat (*Corynorhinus townsendii townsendii*) (fig. 1), a federal and California State species of special concern.

The lava caves are characteristically lava tubes, formed as molten lava flows from a volcanic vent. Lava on the

edges of a flow cools and hardens, eventually creating an enclosed tube after the flow of lava from the vent subsides and the molten lava evacuates the inside of the tube onto the surrounding landscape. Sections of these tubes may collapse soon after cooling or while still flowing with lava, creating cave entrances (fig. 2). The cave environments are diverse in terms of internal climate, size, and size of

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Figure 1. Lava Beds National Monument in northern California is a stronghold for Townsend's big-eared bat, a federal and California State species of special concern. In 1996, staff at the national monument began monitoring population dynamics of this special wildlife resource with the goal of ensuring its long-term survival.

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Though this species has experienced a significant decline in numbers elsewhere in the western United States as a result of habitat destruction and roost disturbance (Pierson and Fellers 1998), Lava Beds National Monument is a stronghold for it. Some of the caves support maternal colonies in summer and others support hibernating populations in winter; additionally, adult males and yearling non-reproductive females form small, scattered bachelor groups in summer apart from the maternal colonies.

Despite their presence at Lava Beds, maternal and hibernating populations of this species are susceptible to disturbance by humans and may be vulnerable to slight changes in cave habitat environmental conditions such as humidity and temperature. These disturbances can result in the bats taking flight and abandoning young or changing roost locations. Hibernating bats are especially vulnerable to disturbance that can cause them to expend valuable energy in the form of stored fat needed to survive winter in the caves.



Figure 2. Townsend's big-eared bats are thriving at Lava Beds National Monument in large part because of abundant, suitable habitat. Lava caves vary in terms of size and internal climate and support maternal colonies in summer and hibernating populations in winter.

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Long-term monitoring

Monument biologists began monitoring population trends of this special wildlife resource in 1996 to guide management actions for the protection of its habitat and to ensure a continued sanctuary for this species. For eight years we conducted summer field monitoring at three Townsend's big-eared bat maternal roost caves (fig. 3), the total number of maternal roost caves for this species in the monument. We determined the presence of the three maternal colonies by conducting cave entrance auditory and activity surveys using bat detectors, which identify high frequency bat echolocation calls. To gather data on the exit flight of the bats from the caves we followed monitoring protocols developed by the monument's Resource Management Division (Baldino 1996a and 1996b) in consultation with the Western Bat Working Group. This group of state and federal agencies, organizations, and individuals is interested in the conservation, research, and management of bats, including Townsend's big-eared bat, in the western United States and Canada. Night-vision equipment and hand-held counters enabled us to count bats as they exited maternal cave roost sites during the summer breeding period from April through September.

Maternal colonies consist of pregnant and nursing females and their pups and range in size from approximately 100 to more than 300 individuals. To determine reproductive success, we counted adult females during the early part of the breeding season, before the pups were born. We estimated reproductive success later in the season when the pups were able to fly and exit the caves to feed on night-flying insects. By comparing the early-season exit flight numbers with those late in the season we estimated annual reproductive success.

Population trends

We conducted extensive cave reconnaissance surveys throughout the monument to locate all Townsend's big-eared bat maternal colonies and hibernation sites and identified three distinct maternal colonies. Over a period of 12 years (including observations made before intensive monitoring began in 1996), we noted a consistent pattern of use of specific caves by the maternal colonies. Identifying the three maternal colonies was important for sampling population trends because the counts can be repeated at these sites and compared from year to year.

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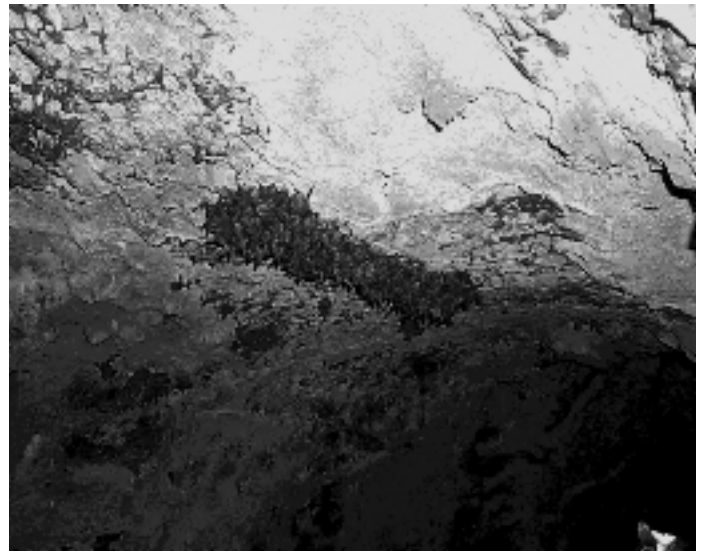


Figure 3. A Townsend's big-eared bat maternal colony at a cave roost site at Lava Beds National Monument.

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Monitoring of bat hibernation site populations can also provide a reliable population trend estimate over time. Male and female bats roost together at these sites, where mating takes place.

However, surveys of hibernation sites conducted in the interior of the caves can have greater potential for causing disturbance than those of maternal colonies and therefore are not conducted regularly.

Collected from 1996 to 2003, the monitoring data suggest that the populations of Townsend's big-eared bats at Lava Beds National Monument are relatively stable, with small annual fluctuations. As shown in figure 4 (page 50), error bars overlap, indicating no significant difference between years. Totals for annual population of the maternal colonies are documented from exit counts and shown in figure 5 (page 50).

Though comprehensive monitoring of this species ended with the 2003 field season, maternity counts continue on a limited basis at the monument today. In 2004, the population estimate at one maternity roost site did not differ significantly from those made 1996–2003.

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Cave roost preferences

Townsend's big-eared bats are known for roost fidelity, and at Lava Beds the maternal colonies and hibernating bats returned to



the same caves on an annual basis. Though cave environmental conditions are important factors that can affect reproductive success, this regular pattern of returning to the same roost site suggests conditions are favorable for the maternal and hibernating bats. Pregnant and nursing female big-eared bats roost very close to each other, apparently maintaining a microclimate within these colonies with the heat radiated from their bodies. This microclimate is critical for keeping the pups warm until they are sufficiently developed to fly and forage for insects on their own. Monitoring indicated that average to high humidity (approximately 50%–100%) and moderate temperatures (approximately 50°F–75°F or 10°C–24°C) generally prevailed in maternal roost caves, while high humidity (approximately 80%–100%) and low temperatures (approximately 30°F–38°F or -2°C–3°C) were common conditions in caves used by hibernating bats at Lava Beds.

An example of environmental conditions preferred by one maternal colony at Lava Beds is shown in figure 6. The maternal colony at this site formed in late April and left the cave in late May. It moved to two other caves before returning to the first cave in mid-August, remaining until mid-September. Because young may be born from late May through July (Nowak 1994), the pattern of changing roost sites during the breeding season may be a result of fluctuating cave environmental conditions and environmental requirements of the maternal colony. The bats may prefer higher humidity and lower temperature at the beginning of the breeding season, whereas lower humidity and higher temperature may accommodate them better late in the season. Furthermore, past experience with environmental conditions in a variety of cave roost sites in the monument may play a role in their movements among those sites. We observed this pattern of maternal colonies of Townsend's big-eared bats changing roost sites throughout the breeding season in all of the colonies.

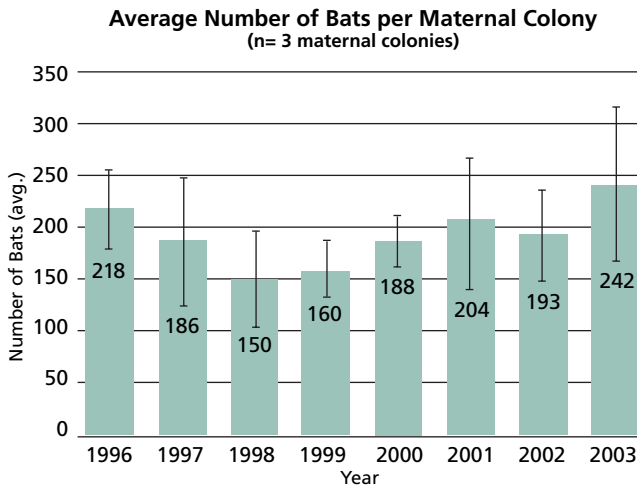


Figure 4. Population averages of three maternal colonies of Townsend's big-eared bats at Lava Beds National Monument. Error bars represent ± 1 standard deviation.

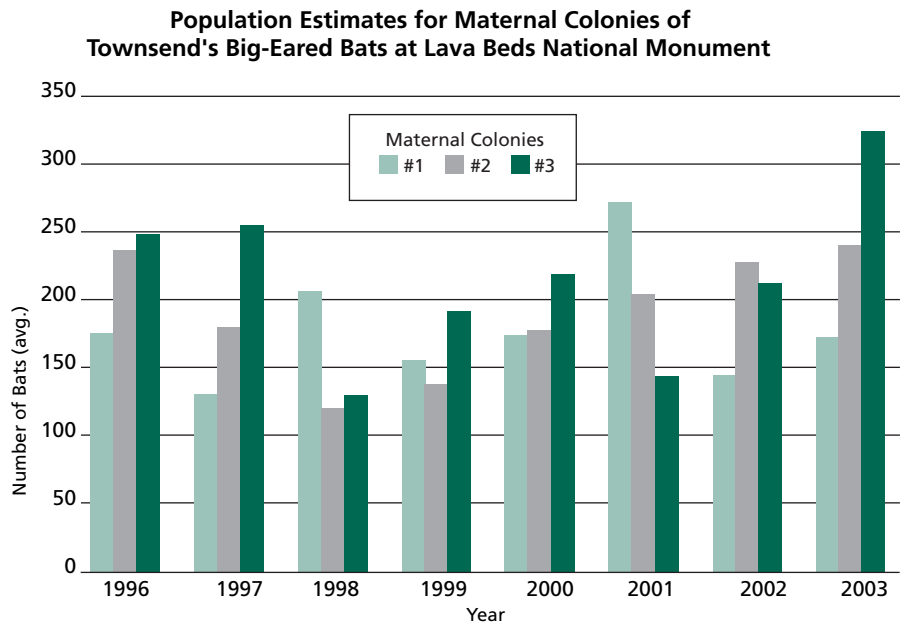


Figure 5. Population estimates for maternal colonies of Townsend's big-eared bats at Lava Beds National Monument.

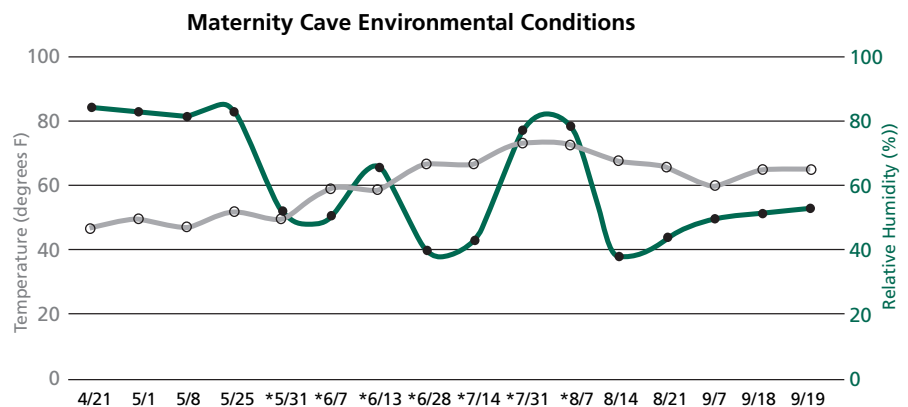


Figure 6. The graph shows cave temperature and relative humidity conditions for one of the maternal colonies being monitored. The dates represent a confirmed occupation of three caves by one maternal colony. The dates with asterisks represent conditions in other maternal caves where the colony moved.

Habitat protection measures

Information from monitoring has influenced management actions at Lava Beds to increase protection of this sensitive species. For example, caving is an activity enjoyed by many visitors to the monument. Cavers can unwittingly disturb cave roosting maternal and hibernating bats. As already discussed, roost disturbance has been linked to declines in Townsend's big-eared bats elsewhere in the western United States. To ensure an undisturbed habitat, which is critical to this species' survival, specially designed gates have been installed at some cave entrances to keep people out but to allow bats to enter and exit naturally. Monument personnel also post closure signs at entrances to maternal caves in the spring and hibernation site caves in the fall. These signs inform visitors of the protected status of the respective caves and the devastating effects of disturbing Townsend's big-eared bat roosts. In addition, staff seasonally patrol maternal and hibernation site cave entrances to check for indications of disturbance and to educate visitors about the sensitive maternal bat colonies.

Public outreach and education are a part of visitor contact programs at the monument's visitor center, on interpretive cave tours (fig. 7), during field interactions between visitors and resource protection rangers, and as a part of summer campfire talks. Monument staff has also developed and presented education programs for local environmental conferences, meetings, and schools to promote public awareness of the benefits of bats, their biology, and conservation, and the ongoing bat research at Lava Beds.

In summer 2004 the monument launched a project that offers further protection for maternal bat colonies through the use of radio technology. Sensors were placed at several cave entrances that have been closed to protect Townsend's big-eared bat maternal roosts. When triggered by human foot traffic near these cave entrances the sensors transmit signals to the two-way radios of law enforcement rangers, indicating trespass at a specific cave. Resource protection rangers then respond to the cave entrance to prevent disturbance of the maternal colonies. In 2004, they made more than 40 sensor-related contacts with visitors to the monument.

Maternal and hibernating populations of this species are susceptible to disturbance by humans and may be vulnerable to slight changes in cave habitat environmental conditions such as humidity and temperature [that] can result in the bats taking flight and abandoning young or changing roost locations.

Protection measures employing modern technology and staff vigilance are helping to ensure that the Townsend's big-eared bat population at Lava Beds National Monument is not disturbed and that the monument will remain a refuge for this species of special concern.

Eight years of monitoring the maternal population dynamics of this sensitive species has identified this population as a stable one. In addition, cave roost environmental monitoring has given us insight into the preferred cave roost conditions of Townsend's big-eared bats. Outreach efforts support management of this species and will provide

future benefits for conservation of all bat species beyond the boundaries of Lava Beds National Monument.



Figure 7. Guided cave tour at Lava Beds National Monument.
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Sensors were placed at several cave entrances that have been closed to protect Townsend's big-eared bat maternal roosts. When triggered by human foot traffic near these cave entrances, the sensors transmit signals to the two-way radios of law enforcement rangers indicating trespass at a specific cave.



References

- Baldino, C. 1996a. Bat monitoring protocols. Unpublished report. Lava Beds National Monument, Tulelake, California.
- Baldino, C. 1996b. Bat survey protocols. Unpublished report. Lava Beds National Monument. Tulelake, California.
- Nowak, R. M. 1994. Walker's bats of the world. Johns Hopkins University Press, Baltimore, Maryland.
- Pierson, E. D., and G. M. Fellers. 1998. Distribution and ecology of the big-eared bat, *Corynorhinus (Plecotus) townsendii* in California. U.S. Geological Survey Species at Risk Program, Washington, D.C.

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Population dynamics of Mexican free-tailed bats at Lava Beds

By Kelly Fuhrmann

In addition to its population of Townsend's big-eared bats, Lava Beds National Monument is home to Mexican free-tailed bats (*Tadarida brasiliensis mexicana*). Adult females of this species arrive at the monument in mid- to late June. The colony probably migrates between Lava Beds and central and southern California (Denny Constantine, researcher, personal communication, 1999). The pups are born within three weeks of arrival of the adults and continue to develop for six to eight weeks after birth. They become volant (i.e., they begin flying) during this time and develop the skills necessary to forage for food with adult bats.

At more than 164,000 individuals, this seasonal maternal colony is the largest and northern-most in far western North America (Cross 1989). Researchers have yet to fully understand all of the ecological implications of this bat colony in the region; however, one undeniable benefit is the bats' service to local agriculture as natural crop pest insectivores. Analysis of radiotelemetric data has determined that during exit flights from the lava cave the colony disperses over the agricultural fields of the Tule Lake basin. The adult females initially, with the volant young later in the season, emerge from the cave around sunset each evening to feed on insects (see photo). Given the number of bats present, this maternal colony consumes as much as 200 tons (181 tonnes) of insects during the summer season.

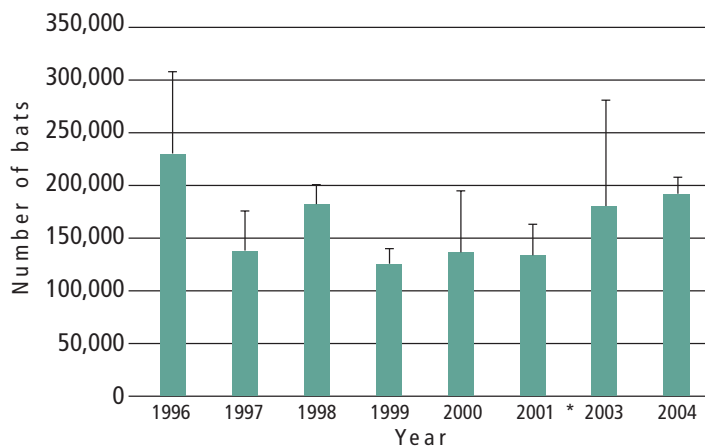
Population studies of this seasonal colony of migratory Mexican free-tailed bats began in 1988 when Dr. Steven Cross of Southern Oregon University collected baseline data. Dr. Cross used still-photo sampling protocols for monitoring the exit flights on an annual basis during the maternal season and completed an initial analysis of this colony's population. Researchers have since developed variations of this protocol for other bat population monitoring projects (O'Shea and Bogan 2003). Cross's 1988 data identified an average population of 149,681 adult bats. The still-photography method allows comparison of population estimates made



Since consistent monitoring began, the data demonstrate that the annual returning adult population of the colony is variable but stable (see graph). The population estimates gathered from 1996 to 2004 identify an average annual population of 164,816 adult bats. Several factors may contribute to the fluctuations in numbers. One is that the maternal colony is subject to a host of environmental influences inside and outside the maternal roost that may impact populations (e.g., pesticides, prey availability, water quality, and cave climate). Additionally, the migratory flight, winter roost conditions, and summer roost fidelity behavior may have an impact on colony numbers. Finally, annual reproductive rates and pup survivability also affect the annual variations in population.

The data gathered from monitoring provides natural resource managers with the information necessary for refining field protocols, assessing health of bat populations, and planning future management and protection such as habitat conservation. Other research projects associated with this colony have included foraging behavior, impacts of agricultural practices, and utilizing thermal imaging technology to assess population dynamics. Thermal imaging technology holds great promise for accurately estimating bat populations (Kunz 2003). The value of this data and findings from related studies is found in their use as an educational tool for natural resource managers and the public. By learning more about bat populations and behavior, researchers and park staff will better understand the ecological role of bats. Continued monitoring of this bat colony will further define the trend in population dynamics of the returning adult bats of this maternal colony.

Population dynamics of adult Mexican free-tailed bats at Lava Beds National Monument



* Data from 2002 are not represented because of limited collection due to colony exit-flight behavior.

early in the season, which exclude pups, with those that include them later in the season.

In 1996 park staff began consistently monitoring the colony. The goal has been to accurately estimate the returning population of adult females and their reproductive success for the season. Biologists usually sample the returning adult female population in July. They determine reproductive success after additional sampling in late August or early September when exit flights include young of the year. Various environmental and data-collection variables such as weather conditions, exit-flight timing and behavior, equipment operation and limitations, methodology, and personnel changes influence the monitoring work.

References

- Cross, S. 1989. Studies of the Mexican free-tailed bat, Lava Beds National Monument: measuring population levels and influencing factors. Unpublished final research report. Lava Beds National Monument, Tulelake, California.
- Kunz, T. H. 2003. Censusing bats: challenges, solutions, and sample bias. Pages 9–17 in T. J. O’Shea and M. A. Bogan, editors. Monitoring trends in bat populations of the United States and territories: problems and prospects. Information and technology report USGS/BRD/ITR-2003-0003. U.S. Geological Survey, Biological Resources Division, Springfield, Virginia.
- O’Shea, T. J., and M. A. Bogan. 2003. Monitoring trends in bat populations of the United States and territories: problems and prospects. Information and technology report USGS/BRD/ITR-2003-0003. U.S. Geological Survey, Biological Resources Division, Springfield, Virginia.



Partnership in reforestation at Timucuan

Ecological and Historic Preserve

By Daniel R. Tardona and Richard Bryant

Timucuan Ecological and Historic Preserve in Jacksonville, Florida, was established in 1988 to protect one of the last unspoiled coastal wetlands on the Atlantic Coast (fig. 1). The 46,000-acre (18,616-ha) preserve contains nationally and regionally significant natural and cultural resources, including the lower Saint Johns River estuary, coastal uplands (which land development and a legacy of fire suppression are causing to disappear), Native American (Timucua) resources, early European settlements (e.g., Fort Caroline), and a cotton plantation site (Kingsley Plantation).

Timucuan is a nontraditional unit of the National Park System consisting of publicly and privately owned lands. This unit depends upon cooperative relationships with state and local governmental and non-governmental entities, including businesses like the Castleton Beverage Corporation, for managing lands within and adjacent to the preserve boundary. Reforestation of the Thomas Creek area of the preserve is an example of the kind of successful working partnership that is needed to fulfill preservation goals.

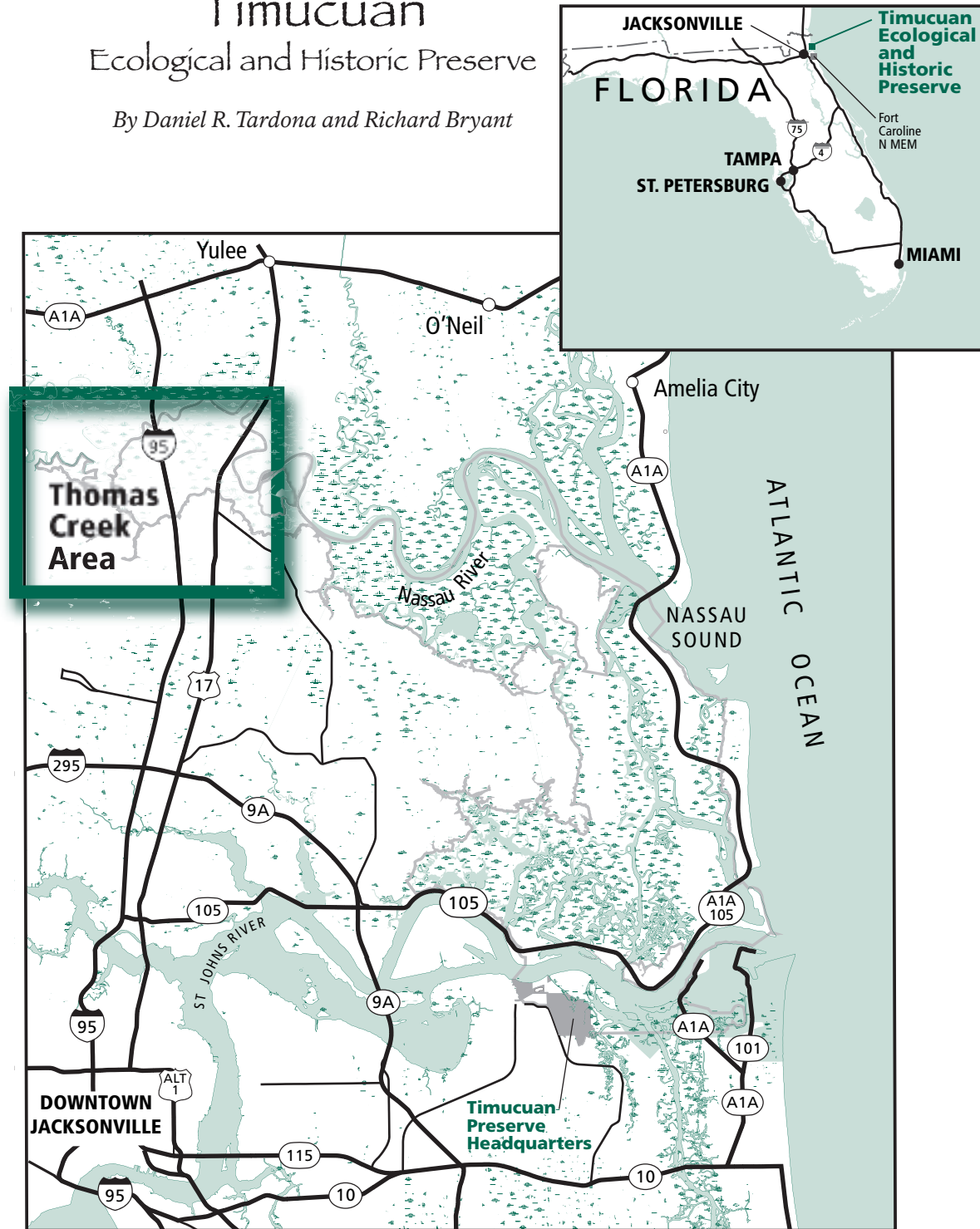


Figure 1. The 46,000-acre (18,616-ha) Timucuan Ecological and Historic Preserve in Jacksonville, Florida, preserves nationally significant natural and cultural resources. Natural resources include coastal wetlands and uplands; cultural resources include artifacts of Native American and European settlers, as well as the site (yet unidentified) of the southernmost battle of the Revolutionary War. Inset shows the Thomas Creek area, which the National Park Service is restoring to pre-settlement conditions in cooperation with Castleton Beverage Corporation.

Background

As reported in Tardona (1997), the National Park Service entered into a partnership with the Castleton Beverage Corporation, which owned approximately 927 acres (375 ha) of ecologically and culturally significant land within the preserve boundary. The project site, known as the Thomas Creek area, contains a 27-acre (11-ha) lake, 262 acres (106 ha) of freshwater wetlands, and approximately 145 acres (59 ha) of brackish salt marsh. Culturally, the area is thought to be associated with the historic southernmost battle of the Revolutionary War; however, no one has located the battle site yet.

Park managers reached an agreement with the corporation to allow the seller to harvest planted loblolly pines (*Pinus taeda*) seven years after completion of the sale. This agreement was mutually beneficial. From the perspective of the National Park Service, it created an opportunity to reforest the area without having to bear the cost of tree removal. The harvest eliminated unwanted trees, which Timucuan Ecological and Historic Preserve may not have gotten the funds to remove. From the Castleton Beverage Corporation's perspective, the agreement enabled it to recover its investment of land preparation and planting by waiting until the planted trees reached merchantable value as pulp. Thereby, Castleton recouped the value of the trees, approximately 1,000 trailer loads of pulp wood with some saw timber (primarily from the shelter wood cuts) that were trucked to the mill. The harvest provided the National Park Service with a means to reforest the area with a historically appropriate tree species, native longleaf pines (*Pinus palustris*), as opposed

to "inheriting" a huge tree farm with little natural or cultural resource value (fig 2, page 56). The development of a mutual understanding of the goals and

The development of a mutual understanding of the goals and needs of both parties ... has carried the project through.

needs of both parties began a reciprocally beneficial, respectful, and cooperative working relationship that has carried the project through.

Harvest methods

As a condition of the sale, the Castleton Beverage Corporation was responsible for coordinating the harvest, subsequent site preparation, and planting of longleaf pine, an appropriate pre-settlement condition for the site (Bartrum 1776) and consistent with Timucuan's general

management plan objectives. Staff from the National Park Service and Castleton Beverage Corporation completed a vegetation management plan prescribing time lines and general objectives (Tardona et al. 1996). This plan outlined the areas to be clear-cut, partially cut (shelter wood), and not cut. The plan also contained guidance on how to intermittently plant the longleaf pine in a random fashion so as to mimic natural regeneration and prevent a predictable pattern. None of the site preparation or planting costs was borne by the National Park Service. Had it been otherwise, the reforestation project might have been precluded.

Timber harvest started in July 2002 by a contract logging firm hired by Castleton. In August, heavy rains resulted in poor road conditions and the National Park Service asked the contractor to halt operations until the roads dried out. Harvest resumed in April 2003 and was completed by June 2003 (fig 3, page 56). Harvest was totally mechanical and usually consisted of a feller-buncher (wheeled vehicle that grabs, cuts, and lays the trees down), one or two skidders (wheeled vehicles that drag the felled trees to the loading site), and one loader (a hydraulic, articulated claw arm that picks up trees and places them onto transport trailers). A total of 293 acres (119 ha) was clear-cut while 80 acres (32 ha) were left as shelter wood.

In a give-and-take relationship, the National Park Service and Castleton Beverage Corporation worked together to find solutions for a situation that could have easily ended in disputes. Numerous on-site meetings and observations of what both parties wished to gain from the project fostered this cooperative working partnership.

Site preparation

Upon completion of the timber harvest, Castleton had the responsibility of preparing the site for planting. Although the timber harvest resulted in large piles of tree tops and limbs, the 1996 plan did not specify what was to happen to these piles. Burning is not permitted because of the proximity of the site to Jacksonville International Airport and Interstate 95. Furthermore, off-site disposal was considered impractical. Therefore, the piles were scattered with a front-end loader followed by crushing with a roller-chopper. This treatment scattered the brush over the entire clear-cut area and facilitated decomposition and recycling of nutrients back into the soil. Cost for the scattering was \$3,000. The 46,000-pound (20,865-kg) heavy-duty roller-chopper, which was pulled across the clear-cut sites with a large bulldozer (D-8), broke up the stumps and mounds (rows) on which the loblolly pines had been planted. Cost of roller chopping was \$60 per acre (\$148 per ha) or \$10,500 total.





Figure 2. Before harvesting, the 275-acre (111-ha) Thomas Creek area contained loblolly pine planted on beds in rows 12 feet (3.7 m) apart, with trees planted approximately 6 feet (1.8 m) apart. The Castleton Beverage Corporation, an inholder at Timucuan Ecological and Historic Preserve at the time of planting, ultimately harvested the trees for pulp. DANIEL R. TARDONA

Tree planting

In addition to historical documentation (Bartrum 1776), analysis of soils and surrounding undisturbed areas suggested longleaf pine savanna as the appropriate habitat for this site (Boyer 1984, Spurr and Barnes 1980). Therefore, the NPS goal was to restore the site to such conditions.

The 1996 plan called for the establishment of longleaf pine forest in areas where the loblolly pine was clear-cut. To mimic seed scatter from large longleaf trees throughout the site, workers placed a total of 229 metal fence posts at random locations throughout the clear-cut areas. This guided the “planting hoe,” called a dibble, which inserted pine tubules into the ground. Cost of posts and labor was \$2,400. Using these posts as visual guides, the planter placed a minimum of 100 seedlings within a 100-foot (30-m) radius of each post. The planter selected “micro-sites” where the seedlings had the highest probability of survival. Cost of the containerized seedlings was \$0.135 per tree totaling \$3,375 for the 25,000 seedlings planted. Cost of planting was \$0.24 per seedling (total \$6,000). The first phase of planting was completed in October 2003 (fig. 4).

The 1996 plan calls for subsequent seedling plantings three and seven years after the initial planting. One of the preliminary concerns of the longleaf pine

Analysis of soils and surrounding undisturbed areas suggested longleaf pine savanna as the appropriate habitat for this site.

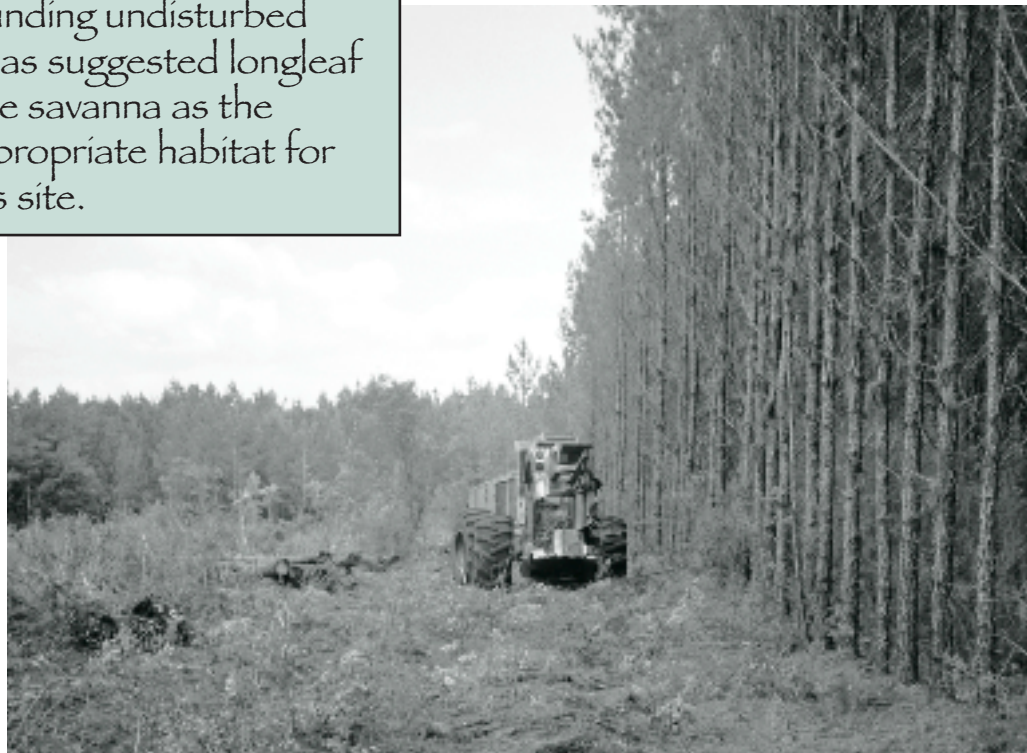


Figure 3. During the harvest, a feller-buncher cut selected trees. As part of site preparation for restoration, a roller-chopper flattened the high bed rows upon which loblolly trees had been planted. RICHARD BRYANT

restoration was that this species is classified as a sub-climax species dependent upon recurring fires for perpetuation (Spurr and Barnes 1980). Because of the proximity of the property to Interstate 95 and the Jacksonville International Airport, prescribed fire is not a viable option. Therefore, both parties agreed to increase the number of seedlings planted in the first year, from 60 seedlings per “seed-tree site” to 100 seedlings. Castleton has donated sufficient funds to the National Park Service for planting 20,000 additional trees beginning in 2006.

In an effort to establish longleaf pine in the absence of fire, park managers decided to employ two different planting methods. In the smaller eastern area of approximately 49 acres (20 ha), contractors planted longleaf seedlings immediately after harvest and crushing. The larger western cleared area of approximately 244 acres (98 ha), which had also been treated with a roller-chopper, was allowed to lie fallow for six months and then planted with seedlings. Park staff will compare and evaluate survivorship of seedlings in the two areas before subsequent plantings. Depending on the results, managers will select the method to be used during future plantings. Initial casual observations suggest that seedlings in the eastern area, which were planted immediately after harvest, are having a higher survival rate than those in the western site where land remained fallow for six months prior to planting.

Observations and management challenges

The disturbance of harvesting appears to have resulted in an unexpected benefit. Native wiregrass (*Aristida stricta*) has proliferated. Some important management challenges, nonetheless, exist. Wiregrass will not enter the reproductive phase unless burned, defoliated, or disturbed (Parrott 1967). Exotic plants have also invaded the site, the most prominent being Chinese tallow (*Sapium sebiferum*). Park staff is seeking funding to control the spread of this ornamental, fast-growing, small- to medium-sized tree at the site. The nearby Interstate 95, where mowing often takes place, is a potential source of invasive species, and monitoring for spread into the Thomas Creek area is necessary.

With regard to longleaf pine, the goal is survival of at least 30% of the planted seedlings, ensuring the establishment of longleaf pine and associated native vegetation such as wiregrass. Because widespread use of prescribed fire at the site is not possible, park staff is exploring the use of mowing and herbicide for preventing competing vegetation from overlapping the longleaf pine seedlings. In the future, if longleaf survivability falls below 30%, park staff may treat small plots with prescribed fire on a very limited basis to reduce competing vegetation.

Summary

While management challenges remain to ensure healthy reforestation, the project has been a success on many fronts. The National Park Service obtained desired land at a reduced price, and Castleton Beverage Corporation was able to recoup forest development costs. Additionally, the National Park Service did not have to use government funds to initiate the reforestation of a native longleaf pine savanna.

The project has resulted in the development of a positive relationship between the National Park Service and a portion of the local community that could easily have been at odds with the mission of the National Park Service and Timucuan Ecological and Historic Preserve. This very relationship will serve as a model for future partnerships

Figure 4. As part of restoration of the Thomas Creek area, contractors planted 25,000 longleaf pine seedlings in October 2003. In order to imitate natural, intermittent regeneration, 10,000 additional trees will be planted in 2006 and another 10,000 in 2010. DANIEL R. TARDONA



between the National Park Service and other potential partners in the region. The partnership achieved cost savings for both the government and the community. Moreover, this effort improved natural resources, including vegetation, wildlife, and scenic values, and the opportunity for public enjoyment of the Thomas Creek area. Perhaps unknown cultural resources hidden in the previously disturbed area may come to light.

Staff at Timucuan Ecological and Historic Preserve is accomplishing the goals for the Thomas Creek restoration area by working cooperatively and in partnership with a major local business corporation, which was a former landowner and is a current holder of land adjacent to the preserve. The project clearly demonstrates that partnerships between the National Park Service and private industry can be effective where each partner has a role in the project. The shared goal of harvesting the trees (though for different reasons) encouraged both entities to be committed to working as a team, sharing expertise and resources, and agreeing to clearly defined expectations (fig. 5). Mutual respect and trust for the missions of the park and Castleton Beverage Corporation fostered a spirit of cooperation and sometimes compromise. Ultimately, the result will be accomplishing a specific component of the Timucuan Preserve and NPS mission: to improve and sustain the resource conditions of the Thomas Creek area carried out in accordance with established NPS management policies and standards.

This ... relationship will serve as a model for future partnerships between the National Park Service and other potential partners in the region.



Figure 5. Staff at Timucuan Ecological and Historic Preserve is working cooperatively with a major local business, Castleton Beverage Corporation, to restore the Thomas Creek area. The corporation was a former landowner and is a current holder of land adjacent to the preserve. Staffs from Castleton and the preserve have conducted many on-site meetings during the reforestation process. DANIEL R. TARDONA

References

- Bartram, J. 1776. Diary of a journey through the Carolinas, Georgia, and Florida from July 1, 1765, to April 10, 1766. Annotated by Francis Harper. Transactions of the American Philosophical Society 33, part 1 (December 1942):1–120.
- Boyer, W. D. 1984. First-year survival of planted longleaf pine bare-root and container stock as affected by site preparation and release. Proceedings of the third biennial southern silvicultural research conference, November 7–8, Atlanta, Georgia. USDA Forest Service, Asheville, North Carolina.
- Parrott, R. T. 1967. A study of wiregrass (*Aristida stricta* Michx.) with particular reference to fire. MS thesis. Duke University, Durham, North Carolina.
- Spurr, S. H., and B. V. Barnes. 1980. Forest ecology. 3rd edition. John Wiley & Sons, Inc., New York.
- Tardona, D. R. 1997. A nontraditional cooperative approach to natural resource management. Park Science 17(1):11.
- Tardona, D. R., H. T. Remaley, and E. B. Hicks. 1996. Vegetative resource management plan for the Thomas Creek area, Timucuan Preserve. Natural resource report. Timucuan Ecological and Historic Preserve, Jacksonville, Florida.

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Meetings of Interest*

- March 27–30, 2006** The International Association of Wildland Fire—a nonprofit professional association representing members of the global wildland fire community—is hosting the First Fire Behavior and Fuels Conference in Portland, Oregon. The theme of the conference is “Fuels Management: How to Measure Success.” The planned sessions highlight development, implementation, and evaluation of fuels management programs. The evaluation portion focuses on how to measure the success of programs that are designed to reduce risks to communities and to improve and maintain ecosystem health. More information is available at <http://www.iawfonline.org/fuels/overview.shtml>.
- March 22–25** The Wildlife Management Institute announces the 71st Annual North American Wildlife and Natural Resources Conference, which serves as the premiere annual forum for the gathering of North America’s leading scientists, managers, educators, and administrators of wildlife and other natural resources. Sessions at the Columbus, Ohio, meeting will explore the theme, “Natural Resource Conservation: The Other Homeland Security,” and cover such issues, policies, and practices as “When Wildlife and Human Interactions Lead to Crisis,” “Resource Agency Accountability,” and “From Landscapes to Riverscapes: Adding Fish to the Mainstream of Habitat Initiatives.” More information is available at <http://www.wildlifemanagementinstitute.org/pages/TOC.html?168,149>.
- April 4–6** Integrated Pest Management (IPM) is a long-standing, science-based decision-making process that identifies and reduces risks from pests and pest management-related strategies. The Fifth National IPM Symposium, “Delivering on a Promise,” is being held in St. Louis, Missouri. Symposium sessions outline state-of-the-art strategies and technologies to successfully solve pest-related problems in agricultural, recreational, natural, and residential settings. The symposium provides the opportunity for researchers, educators, government officials, industry representatives, and environmental and health advocacy professionals to share information, network, and organize activities on key pest management issues. More information is available at <http://www.ipmcenters.org/ipmsymposium/>.
- May 8–10** The use and growth of Geographic Information Systems (GIS) in water resources has grown exponentially in the past decade, resulting in GIS becoming an essential tool in water resource planning and management. Hence, the American Water Resources Association is hosting GIS and Water Resources IV in Houston, Texas. Presentation topics cover the National Hydrography Dataset (NHD), land-use classification, remote sensing, homeland security (e.g., infrastructure mapping, vulnerability analyses, and spill response), lidar and ifsar, FEMA map modernization, and temporal mapping (e.g., creating and managing data sets, real- and near-time predictive modeling, flood forecasting, and mechanics and math behind-time dependent modeling). More information is available at <http://www.awra.org/meetings/Houston2006/index.html>.
- May 14–19** The U.S. Geological Survey and partners are hosting the 14th International Conference on Aquatic Invasive Species in Key Biscayne, Florida. The conference addresses the worldwide problem of the introduction and spread of nonnative species in freshwater and marine environments. Over the last decade, this conference has developed into the most comprehensive international forum for the review of scientific knowledge and the presentation of the latest field and laboratory research on invasive species in aquatic systems. During the conference, participants will discuss new technological developments of species control and mitigation, policy, and legislation to prevent new introductions, and public education and outreach initiatives to raise awareness about aquatic invasive species. More information is available at <http://www.icaais.org/>. 

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



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