CROSSING BOUNDARIES IN PARK MANAGEMENT

PROCEEDINGS OF THE 11TH CONFERENCE ON RESEARCH AND RESOURCE MANAGEMENT IN PARKS AND ON PUBLIC LANDS

EDITED BY DAVID HARMON

THE GEORGE WRIGHT SOCIETY
BIENNIAL CONFERENCE
DENVER, COLORADO APRIL 2001

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Crossing Boundaries in Park Management: Proceedings of the 11th Conference on Research and Resource Management in Parks and on Public Lands

Edited by David Harmon

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… to see old ideas in a new light

1 Editor's introduction

David Harmon, *The George Wright Society, P.O. Box 65, Hancock, Michigan 49930-0065; dharmon@georgewright.org*

"Crossing Boundaries in Park Management: On the Ground, In the Mind, Among Disciplines," the George Wright Society's biennial conference, was held in Denver, Colorado, April 16-20, 2001. This was the 11th in a series of conferences dating back to 1976. They have been organized since 1982 by the GWS. The next (12th) conference will be in San Diego in April 2003.

The Denver meeting drew over 730 people, the largest attendance since the 2nd conference in 1979. To judge from the comments received on the conference evaluation questionnaire, it was an extremely productive and rewarding week for the participants. There were four plenary sessions, 70 concurrent sessions, a poster and computer demo session that drew 60 presenters, and numerous side meetings and special events. In all, over 300 presentations were made during the week. The GWS conference has grown over the years to become the USA's largest interdisciplinary professional meeting on protected areas.

This proceedings volume contains the 71 papers that were received before the submission deadline. I think they give a good idea of the range of conference. My role as editor has been to set the order of the papers and copyedit them.

By prior arrangement, the papers presented in the conference's concurrent session #50, titled "Passport to the Future: Crossing Boundaries in Managing Recreational Use of National Parks and Related Areas," were published in the Society's quarterly journal, THE GEORGE WRIGHT FORUM (Volume 18, Number 3, September 2001). The concurrent session was organized by Robert Manning, and he guest-edited the theme issue of the journal. The papers included are:

- Introduction: crossing boundaries in managing recreational use of national parks and related areas / *Robert Manning*
- Crossing experiential boundaries: visitor preferences regarding tradeoffs among social, resource, and managerial attributes of the Denali wilderness experience / *Steven Lawson and Robert Manning*
- Integrating resource, social, and managerial indicators of quality into carrying capacity decision-making / *Peter Newman, Jeffrey L. Marion, and Kerri Cahill*
- Managing national parks in a multicultural society: searching for common ground / *Myron F. Floyd*
- Integrating subsistence use and users into park and wilderness management / *Daniel Laven, Robert Manning, Darryll Johnson, and Mark Vande Kamp*
- Norm stability: a longitudinal analysis of crowding and related norms in the wilderness of Denali National Park and Preserve / *James Bacon, Robert Manning, Darryll Johnson, and Mark Vande Kamp*
- Crossing methodological boundaries: assessing visitor motivations and support for management actions at Yellowstone National Park using quantitative and qualitative research approaches / *William Borrie, Wayne Freimund, Mae Davenport, and Robert Manning*
- Thinking and acting regionally: toward better decisions about appropriate conditions, standards, and restrictions on recreation use / *Steven F. McCool and David N. Cole*

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- Diversity in outdoor recreation: planning and managing a spectrum of visitor opportunities in and among parks / *Cynthia Warzecha, Robert Manning, David Lime, and Wayne Freimund*
- Conserving recreation diversity: collaborating across boundaries / *Glenn E. Haas*
- Crossing programmatic boundaries: integrative approaches to managing the quality of the visitor experience / *Megha Budruk, Daniel Laven, Robert Manning, William Valliere, and Marilyn Hof*

As with all back issues of THE GEORGE WRIGHT FORUM, this one is available to download from the GWS Web site (www.georgewright.org) as a series of PDF files. Hard copies and CD editions are also available for purchase from the Society. The same goes for this proceedings volume. Orders can be placed over the Web site using a secure order form.

Without volunteers working with the GWS, these conferences could not take place, and we are indebted to many people for their help in Denver. We had invaluable assistance from many National Park Service employees there, but no one was more helpful than Bruce Heise, who assisted with most of the local arrangements and field trips. We also would like to mention the following people who volunteered to help with field trips, the registration desk, and A-V equipment: Leslie Armstrong, Jeff Connor, Tim Connors, Karl Cordova, Theresa Ely, Mark Flora, Larry Gamble, Judy Geniac, Joe Gregson, Roy Irwin, Therese Johnson, Pat Kenney, Ryan Monello, Bruce Nash, Anne Poole, Jean Rodeck, Dave Shaver, David Vana-Miller, Judy Visty, and Ted Weasma. Chuck Rafkind was once again our conference photographer *par excellence.* Others, too numerous to mention, gave help in planning and carrying out the conference. Our thanks go out to them all.

Finally, we are very grateful to our co-sponsors and supporting institution, and to the persons within them who helped arrange funding: National Park Service, natural resources (Mike Soukup, John Dennis); National Park Service, cultural resources (Kate Stevenson, John Robbins); U.S. Geological Survey Biological Resources Division (Denny Fenn); and Eastern National (Chesley Moroz). Without their steadfast support, these conferences could not happen.

David Harmon
Executive Director
The George Wright Society
November 2001

2 Crossing boundaries in park management: conference opening remarks

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Welcome to the biennial conference of the George Wright Society, the 11th Conference on Research and Resource Management in Parks and Public Lands. The George Wright Society has been the sponsor and principal organizer since the third conference. I'm Bob Krumenaker, president of the George Wright Society.

I would like to express my appreciation to the conference co-sponsors, the natural resources and cultural resources directorates of the National Park Service (NPS)—thanks, Mike Soukup and Kate Stevenson—and the U.S. Geological Survey Biological Resources Division (USGS-BRD)—thank you, Denny Fenn. Also to Eastern National (thank you, Chesley Moroz), who is also providing financial support, and the many volunteers from the Denver area, local NPS areas, and beyond, who will be working behind the scenes.

This conference has evolved in a remarkable way since the early days.

In its early years, this was primarily a meeting of National Park Service natural resource specialists and research scientists, who put aside their own squabbling every two years to get together in search of common ground. While they disagreed on many things, the scientists and resource specialists could agree on one thing: if only park managers (those people) would listen to them, things would be different.

Now, however, this has become the pre-eminent meeting of not just those interested in park-related natural resource issues, but also cultural resource professionals, superintendents, and other managers. It is widely regarded as the place to put forth and debate ideas about how to most effectively protect parks and other protected areas, using the best science and scholarship. The presence of park managers as well as the specialists makes this a meeting where common ground is about we, not about them.

I want to share a little about the Society, something we have not talked much about in these conferences in the past.

As the conference has evolved, so has the George Wright Society, to be widely and internationally recognized as the most important organization of park and protected area professionals of all disciplines. Our niche is to bring people together, to foster the network of people and the places we care about so deeply.

We organize this conference, we publish The George Wright Forum, and in the last year have branched out to provide conference-organizing services to the NPS and other agencies. Our membership consists primarily of NPS and BRD professionals, academics, and a small number of folks of similar interests from other U.S. and international agencies and organizations.

I'd like to ask all those of you who support this idea of exchanging the best ideas on park research and resource management, to stand. Congratulate each other: what you do and what you believe in, is a high and honorable calling. Please stay standing.

Those of you who are members of the George Wright Society, please remain on your feet. There are 722 of you around the world, a good percentage in this room. On behalf of the Society, I thank you. And I ask that those of you who join every other year in order to lower the price of your conference registration to now consider re-upping in non-conference years. The rest of you, I invite you to join these outstanding people and this organization. You clearly support its goals, or you would not be here. If you want to see these gatherings and the work of this organization

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continue, we ask for your membership in addition to your participation in our conferences. (It does take money to do all this good work, so your membership helps.) You can sit now.

Members get to determine the direction of the organization and help assure the future relevance, and hopefully success, of our collective goals. Members, of course, vote for the Board, and are encouraged to run for the Board, and be part of the leadership team.

To extend a welcome on behalf of the co-sponsoring agencies, I am delighted first to introduce Karen Wade, NPS Intermountain regional director and a great supporter of the GWS and exemplary park resource management. [Karen Wade spoke briefly.]

Now I'm pleased to introduce Denny Fenn, chief biologist of the USGS-BRD, former NPS scientist and natural resource program manager at the highest levels, board member of the GWS, and member of the conference committee. [Denny Fenn spoke briefly.]

Finally, to introduce our opening plenary speaker, Nora Mitchell, director of the NPS Conservation Study Institute and also a member of the conference committee. [Nora Mitchell introduced David Lowenthal, geographer, historian, and biographer of George Perkins Marsh, who gave the opening plenary address: "Repair the past, reform the future: the watershed stewardship of George Perkins Marsh."]

3 Managing what you don't own: the special challenge of marine protected areas

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The implications of ownership

When you own the land, things are different. In the "bundle of sticks" analogy widely used to describe ownership rights, "fee simple" ownership means you get the whole bundle, the right to decide what happens on that piece of ground. While this control is not absolute, as society places certain restrictions on private landowners in the form of zoning, environmental protection standards, and other community standards that protect public health and safety, landowners are able to decide who can use the land, or not, and whether to sell off or lease some of those rights conveyed by ownership to others.

Lands that become our parks and preserves are generally acquired by governments through purchase or donation. This fee-simple ownership of public parks and other conservation lands provides the clear and unambiguous authority needed to manage lands effectively. If we had to manage parks that were mosaics of privately owned lands, we would have to collect the owners of each parcel every time some management decision had to be made and get the owners to agree to allow that action to occur on their corner of the park. Sounds like a pretty inefficient and cumbersome process, but in some ways, this is what is done when marine protected areas (MPAs) are designated and managed.

Unlike the land, marine waters are already owned by the public, so we need not purchase them in order to protect resources there. While government programs are created to act on behalf of the public in managing these areas, the public retains some important role in guiding management decision-making for these areas. As such, they should, as the owners, be provided opportunities to help guide how these marine areas are managed and protected. Like public lands acquired to create parks and preserves, marine areas are public waters and the interests of the public, the owners, must be integrated into any successful management philosophy for marine protected areas.

Ownership-based management

Most protected areas management decisions are justifiably below the radar of public review. One of the primary jobs of the on-site manager is to manage the day-to-day operations. Most protected areas managers are called to this work as a kind of vocation, and, motivated by this calling, it is almost inevitable that they develop a sense of ownership of the area and its resources. This sense of ownership helps fuel the long hours and dedication to the agency mission that are so critical to getting the job done. One wonders what sort of parks, preserves, and sanctuaries we might have if we didn't hear the managers routinely refer to where they work as "my park" and "my sanctuary."

Some public lands managers have taken the position that even major management decisions could appropriately be made without aggressively seeking specific input from the public, except to satisfy public review process requirements. The thinking

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behind this may be that Congress represents the public when they set up management programs for public lands, and the professional lands manager hired to implement this program brings needed expertise to make these decisions in the interest of the public. Many sound and well-reasoned decisions can be—and have been—made by managers using good judgment and the best available science, the manager acting as a kind of proxy landowner. Often such decisions are made in the face of opposition from a small vocal minority of local users of that area who feel they would be adversely affected by the decision. Having a sense of ownership may make the manager feel more confident in taking a locally unpopular, but in his or her view fully justified, decision. Operating under this management philosophy—what could be termed "ownership-based management"—the public, who in most cases must be coaxed to participate in the process of management of public lands and waters, becomes a silent majority whose interests are represented by the manager. Ownership-based management clearly works best in an atmosphere of trust.

However, the last few decades of U.S. history have made the public less confident that "the government" is representing their interests effectively. Managers sometimes are viewed by the local community as faceless bureaucrats implementing policies made a world away inside the Beltway, and over which they or the on-site managers have little direct influence. These site managers are perceived as being less directly accountable to the public, and because they have been managing protected areas with little direct public involvement, they may not be well known. Nor is it likely that they have had the opportunity to build a relationship of trust with any constituency, or the more valuable commodity of a reputation for being worthy of the public's trust. The public may see the protected areas manager only when a problem arises, and so they tend to associate the protected area with problems.

In addition, in this age of information, there is a greater perception among citizens that natural areas are threatened (or their interests are threatened) and they need to get more involved. This same technology is facilitating the public's ability to get more involved, especially through the web and e-mail. Therefore, the management of public lands has been drifting ever more rapidly toward more owner involvement.

There is another perhaps more insidious problem with relying on the minimal application of the public comment process, as it is often currently implemented, to guide management decisions. It doesn't take long for any manager to know who is likely to comment when a notice is published. It is generally resource users, who are protecting some economic interest, and environmental organizations, who are representing their membership. Depending on the situation involved, there may be others, but certainly without actively seeking out a broader perspective, it is unlikely to come by itself. The limited viewpoints may encompass the opposite ends of the spectrum of potential comment, but is unlikely to include the vast middle ground. This is one of the reasons why we now define "consensus" as when both sides are equally unhappy. Without some sense of where the public is on some issue, the process may simply result in splitting the difference between the extreme views and hoping for the best. However, what we can and are likely to end up with in such a process is less than what is needed to get the job done (Wuerther 1999), but enough to agitate both the users and the environmental organizations. Do this often enough, and credibility erodes.

It's different in the water…

Public waters have rarely, if ever, been managed under an ownership-based philosophy. Managers of public waters have always known who owned the ocean. There is a long history of public ownership of coastal and ocean waters since the 13th century. While archaic and a bit complex, the public ownership of marine areas and resources is very clear and relatively straightforward (see Scott 1988, Archer and Jarman 1992, Britton 1997, and Burger and Gochfeld 1998 for background regarding the history of ownership of marine and coastal waters). However, there are elements of the "public" out there asserting some perceived ownership of these areas and the resources they support. This seems particularly true of those from the commercial fishing industry who have been exploiting specific fishing grounds for generations and seem to have taken the position that they have acquired ownership rights as a result of the longevity of this activity—a kind of ownership by adverse possession. While the courts in the USA have consistently reasserted the public's ownership of marine areas and resources when it has been challenged by the fishing industry (Downs, unpublished memorandum), these "rights" seem to be raised in every controversy, and what could be viewed as political expediency has caused the government to recognize these asserted "rights" and even provide compensation for their loss. If any MPA manager has developed inclinations toward an ownership-based management philosophy, challenges to clear title have made implementation of that philosophy nearly impossible. This is probably why most of the truly bold and innovative management of protected areas has occurred on land ... at least up to this point.

Toward a stewardship-based management philosophy for MPAs

The successful strategies for management of public waters have been more collaborative, transparent, and inclusive than what has generally been used on land, at least in the past. The National Marine Sanctuary System, with almost 30 years of experience in marine protected areas, has learned much about how to effectively manage them. Part of whatever success the sanctuary system has attained can be linked to what could be called a "stewardship" management philosophy. It promotes and maximizes owner involvement in the management of designated sanctuaries and in the evaluation of potential new sites, clearly recognizing that these areas are common property and the more advice that can be solicited from the owners —and as broad a cross-section of them as possible—the more certain sanctuary managers can be about the directions taken in site management and expanding the system.

Strategies for increasing owner involvement

In the management of an MPA there are a multitude of opportunities to maximize owner involvement. While they all take time, money, and staff support, the benefits accrued almost certainly outweigh the costs.

Form and fully use advisory committees. Advisory committees afford tremendous opportunities to interact with others who have some interest in the site and its operation. They can allow site managers and staff to develop relationships with representatives of constituencies, hopefully creating "champions" within those constituencies to advocate for the MPA within those organizations and groups, but at a minimum identifying a person responsible for ensuring that communication happens between the constituency and the MPA manager and staff.

Advisory committees involve considerable challenges, however. For federal programs, there is the issue of the Federal Advisory Committee Act, or FACA. FACA was established, in large part, to be sure that advisory committees are established only when they are truly needed. The clear need for owner involvement has been recognized for MPAs, and Congress went so far as to exempt the National Marine Sanctuary System from the requirements of FACA. However, other federal MPA agencies are still subject (unless they too have a special exemption from Congress) to FACA and this adds a significant administrative burden on the program if they decide to empanel an advisory committee.

Establish volunteer programs. Nothing builds a sense of community around an MPA more than getting owners involved up close and personally. Sometimes even the most ardent critic will become an enthusiastic supporter after he or she has a chance to get wet, get dirty, and get something accomplished. The sites of the National Marine Sanctuary System have a number of excellent volunteer programs. Two examples include:

- In the Florida Keys National Marine Sanctuary, the group "Team Ocean" goes out on the water and provides information about the sanctuary to visitors, and keeps watch over sensitive resource areas.
- "Beach Watch" and "SEALS" are two groups of volunteers at the Gulf of the Farallones National Marine Sanctuary that do surveys of beaches and coastal areas, collect valuable information on presence of tar balls and debris, strandings of marine mammals, visitor use, and a host of other useful information. They receive at least eighty hours of training (more over time) and represent a resource of incalculable value to the sanctuary.

Dive teams, volunteer water quality monitoring programs, natural resource interpreters, and visitor center docent programs can all be great focus points for volunteer involvement.

Education, outreach, and "in-reach." The goal of any MPA should be to develop an informed constituency. The need for effective education and outreach is obvious. Technology is available and continues to emerge that will assist in this effort, including such things as live webcasts of underwater activities at the site, list servers, and web-based forums that provide opportunities to increase the size of the MPA community. These technologies help resolve the problem of reaching out to as much of the public as possible. The web generally provides a great vehicle to share information with a community of support that covers a broad geographic area.

Like outreach, "in-reach," or keeping the agency leadership well informed, is also critical. The swirl of controversy around MPA discussions related to new designations or major management decisions is almost a certainty. Having good lines of communications open and working can help sustain support of agency leadership if they are aware of the good things going on as well as the problems. Providing agency leadership the opportunity to participate in celebrations of successes, and other positive events are also appreciated, and provide opportunities for personal contact with leadership.

Collaborative management. In these days of limited staff and budgets, no one agency can afford to carry the full burden of management of most MPAs. In addition, more emphasis is being placed on establishing networks of MPAs (Barr, in press). Developing partnerships with other agencies, non-governmental organizations, and user groups can help to bring more resources and cultivate support for site initiatives. Along with the obvious economies of scale, establishing a network of managers can be useful to share good (and bad) ideas to implement (or avoid), as well as to possibly gain access to personnel with expertise in areas that may not be represented on staff.

Good research to support good management. Good research is essential for successful MPA management. Most of what we deal with in the marine realm is fraught with uncertainty, and in order to provide the best chance of implementing management measures that are appropriate and necessary to protect site resources, "best available science" must be developed and used. In the marine environment, the costs involved in acquiring good science may be very expensive, but strategic partnerships with universities and agency scientists can help considerably.

Things managers must learn to accept. If there is a downside to increasing owner involvement, it is that the way business is done may have to change. Everything you do will take longer. The time involved in getting and keeping the public engaged in management discussions is considerable, and reaching consensus once you have everyone engaged is not inconsequential with regard to time. Many deliberations simply cannot be rushed, so it is incumbent on managers to get issues on the table as early as possible and effectively facilitate discussions to ensure they are as efficient as possible. Wasting time in the weeds collectively spinning your wheels is not an essential part of the consensus-building process. Educating agency leadership about the longer times required for collaborative processes may also present something of a challenge.

The other inescapable reality is that you may not get what you want. You should be involving the public to ensure the owners have the opportunity to guide your stewardship of the site, not looking for them to simply rubber stamp your view. In order to ensure that you get what you need, you want to determine if some minimal set of management actions are necessary to achieve some goal, and make this clear when the issue is shared with constituencies. Provide a number of options that will achieve the goal, rather than expect to develop the answer out of whole cloth as a result of the public review. To quote some rock and roll philosophers, the Rolling Stones, "You can't always get what you want, but if you try, sometimes you get what you need."

Definition of "public" and some observations on getting out of our own way. Public waters are "common property," or, perhaps more appropriately, "state property" (Burger and Gochfeld 1998). It is important to clearly articulate who we mean by the "public"—those who have common ownership of these resources. Too often, the groups that become the "public" are those who feel they have the greatest stake in the outcome of management decisions, who advocate a special interest and represent some constituency who shares that interest. While there is no doubt these people are "part-owners," they represent only a tiny minority of the true public. For federal protected area programs, the public is made up of the citizens of the USA. That means that managers of public lands and waters should be interested in the views of all the owners, no matter what part of the country they are from or what interests they might have. Local users and interested citizens have enhanced access to managers (and more opportunities to make their position known) and there seems to be a false perception that proximity to a nationally significant resource imbues the locals with some special status regarding that particular piece of public land or water. Sometimes the interests of the local community conflicts with the interests of the larger national community, and care must be taken to address this potential conflict. Managers have a duty to seek out the full spectrum of opinions and interests of the public, and give those perspectives due consideration in deciding which management action is appropriate. National surveys on public attitudes regarding marine conservation and MPAs have been conducted by environmental groups and provide much useful information, offering some insight into where the public is on this issue. It might be more useful and appropriate, however, for MPA agencies to commission their own independent survey or surveys. With the establishment of a National MPA Center and thematic institutes for science and training and technical assistance (under the authority of the MPA Executive Order #13158, issued May 2000), this is a task the National Center might consider undertaking. Getting the bigger picture of owner attitudes and views is not an easy task, but an essential one.

Finally, governments and agencies should review their policies and procedures to ensure that they facilitate rather than impede ownership involvement. One such process already discussed is FACA, which clearly can make soliciting advice from the public more difficult. Another possible impediment is the Paperwork Reduction Act. While the goals of this process are well meaning and perhaps justified in keeping the government from subjecting the public to a multitude of burdensome and intrusive forms requesting information, it may have the effect, by creating a lengthy and complicated approval process for seeking out the advice of the public, of making agencies think twice when they feel they could use some enhanced owner involvement. The public should have every opportunity to provide advice if they are moved to do so. No one should be compelling any citizen to provide input if they are not inclined to do so, at least in the realm of managing protected areas. Governmental processes and policies should make the free exchange of information and ideas as easy as possible. The more open the process is and the more opportunities the public has to participate, the more confident managers can be that their stewardship of public lands and waters reflects the aspirations and views of the owners.

The views expressed herein are those of the author and are not meant to reflect in any way policies, positions or views of the Department of Commerce, NOAA, or any of its sub-agencies.

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4 Site conservation planning for the Potomac River Gorge: A partnership between two national parks and The Nature Conservancy

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The National Park Service (NPS) and The Nature Conservancy (TNC) are jointly planning for the conservation of natural resources at the Potomac Gorge, located in and near Washington, D.C. The planning process entails the integration of NPS's inventory and monitoring (I&M) program and TNC's site conservation planning (SCP) process.

Conservation importance of the Potomac Gorge

Despite its urban location, the Potomac Gorge is one of the most significant natural areas in the National Park System. It extends for 15 miles along the Potomac River from above Great Falls to near Theodore Roosevelt Island, and incorporates sections of Chesapeake and Ohio Canal National Historical Park and George Washington Memorial Parkway.

Because of its unusual hydrogeology, the gorge is one of the country's most biologically diverse areas, serving as a meeting place for northern and southern species, midwestern and eastern species, and montane and coastal species. The extraordinary diversity of the site is exemplified by the 400 occurrences of 200 rare species that have been found there.

In addition, over 25 discrete vegetation communities have been identified in the gorge. Of particular significance are the scoured bedrock floodplain and terrace communities, which are more extensive and well preserved at this site than anywhere else in the USA. Several of these have been tentatively ranked as globally rare.

Joining forces

TNC's long-standing interest in the rare species and communities of the gorge led it to approach NPS about a cooperative planning process that would provide the strongest possible conservation of the site's natural resources, while meeting the programmatic needs of both organizations. Recognition of this novel approach and the gorge's exemplary biodiversity led to the awarding of an NPS grant in 2000 to support cooperative planning. This project is presently underway and is scheduled for completion in August 2001.

The planning processes

NPS and TNC have similar approaches to planning for the conservation of biological diversity: I&M and SCP, respectively. Here's how the terminology compares:

From **Crossing Boundaries in Park Management: Proceedings of the 11th Conference on Research and Resource Management in Parks and on Public Lands,** edited by David Harmon (Hancock, Michigan: The George Wright Society, 2001).

I&M	SCP
· focal resources	· conservation targets
· system health	· viability assessment
· stressors	· threats analysis
· conceptual modeling	· conceptual models
· indicators / monitoring	· measures of success

I&M and SCP differ in several ways, including the types of focal resources or conservation targets that are considered, and the sequencing of planning. SCP also places a strong emphasis on involving key stakeholders—local governments, nongovernmental organizations, user groups, etc.—in plan implementation. This emphasis was a key factor in the decision to use SCP as the planning model for the Potomac Gorge, where there are many well-connected, vocal stakeholders adjacent to or near the site.

SCP's "Five-S" Framework

TNC's SCP process is built on the "Five-S" framework:

- ***Systems***. Systems are the species, communities, and ecosystems, and the natural processes that sustain them, that embody the overall biodiversity of the site. Known as "conservation targets," they organize our thinking about the site and serve as the focus of the plan. We conduct viability assessments of the targets in order to rank their baseline health, against which future changes can be measured.
- ***Stresses***. Stresses are factors that degrade the viability of conservation targets. We concentrate on the most important stresses that result directly or indirectly from anthropogenic causes, and which are currently active or likely will be in the next 10 years.
- ***Sources***. Sources of stress are the causes of the degradation of target viability. Sources can either be active—expected to deliver additional stress in the future—or historical—having previously caused stress that still persists. We identify both proximate and ultimate sources of stress.
- ***Strategies***. Strategies are the types of conservation activities deployed to remove sources of stress (threat abatement) and to diminish or eliminate persistent stresses (restoration), both of which serve to enhance target viability.
- ***Success***. Success measures gauge progress towards sustaining or enhancing the viability of conservation targets, as well as progress towards abating threats to that viability.

Systems (conservation targets) at the Potomac Gorge

The systems or conservation targets selected for the gorge—equivalent to *focal resources* in I&M—are as follows:

- ***Riparian communities.*** These are communities at lower elevations along the river that are flooded more frequently (most having a flood return frequency of less than 25-30 years, with many less than 2-3 years), and are therefore dominated by species typically associated with floodplains. The target consists of both rare riparian communities (e.g., channel shelf xeric savanna, annual herb hydric depositional bar) and plant species (e.g., sweet-scented Indian plantain, *Synosma suaveolens*, and Virginia mallow, *Sida hermaphrodita).*

- ***Terrace communities.*** These are communities at higher elevations along the river that are flooded less frequently (most having a flood return interval greater than 2-3 years, with many greater than 25-30 years), and are therefore dominated by species typically associated with uplands. The target consists of both rare terrace communities (e.g., bedrock terrace rim xeric forest, riverside bedrock outcrop/cliff community) and plant species (e.g., woolly three-awn, *Aristida lanosa*, and buffalo clover *Trifolium reflexum).*
- ***Upland forest blocks.*** Five large, intact tracts of upland forest—Great Falls Park, Turkey Run Park, Riverbend Park, Scotts Runs Nature Preserve, and the Gold Mine Tract—are found at the site. These forest blocks provide habitat for a number of state-listed rare plant species, as well as bird species that have been identified as conservation priorities by the Partners in Flight (PIF) program. In addition, these blocks support significant populations of more common forest species that have significantly declined throughout the eastern USA because of the extensive destruction of forests and the fragmentation of much of what remains.
- ***Tributary stream systems.*** Nearly 25 tributaries flow into the Potomac River within the site. Most are first- and second-order streams that drain small watersheds. As aquatic habitats, these streams harbor fish and invertebrates not found in the river or in wetlands at the site. Their watersheds integrate conditions on much of the land adjacent to the site, which are reflected in the physical, chemical, and biological status of the streams as they flow through the site.
- ***Rare groundwater invertebrates.*** The site harbors numerous occurrences of rare subterranean groundwater invertebrates, most notably amphipods in the genus *Stygobromus*. These species are rare globally or within the state, and are either endemic or narrowly limited in distribution. Their spring and seep habitats are a distinctive natural component of the site, and the gorge is generally regarded as a rich "hotspot" for this fauna.
- ***Anadromous and semi-anadromous fish.*** American shad, hickory shad, striped bass, and white perch are species that spawn principally in the mainstems of major rivers at the head of tidal influence, and thus are diagnostic for the lower end of the gorge. They can be considered keystone species in this stretch of the river, where the eggs, fry, and adults serve as an important food source for other fish and for a variety of invertebrates, birds, and mammals.
- ***Wetlands.*** The Gorge harbors a profusion of wetlands of many types. Depressional wetlands resulting from scouring are especially conspicuous, as are springs and seeps that emerge from both shallow and deeper groundwater sources. Nonetheless, little is known about the site's wetlands, and as a result they are not being actively developed as a target. Funding is being sought to remedy this information gap.

Stresses and sources of stress

SCP next examines the impacts of stresses on the size, condition, and landscape context of targets. We then rank the severity and scope of impact of each stress on each target to ensure that we concentrate on the most significant stresses. Stresses are equivalent to I&M *stressors.*

The planning process then considers what sources are most responsible for impairment of target viability. We rank each source's degree of contribution to a stress, and the irreversibility of that stress, to ensure that we concentrate on the most significant sources. Both NPS and TNC use conceptual ecological models to illustrate the relationships between stresses and sources. The consideration of stresses and sources in combination, sometimes known as "threats analysis," is equivalent to the I&M *stress/response relationship*.

A highly customized spreadsheet application has been developed by TNC to assist in evaluating the complex interplay of stress ranks and source ranks and combining them in various ways. The result is a summary that provides the overall rank of threats and the overall threat status for each target. For the Potomac Gorge, the results are as follows:

Targets	***Threat status***
riparian communities	medium
terrace communities	medium
upland forest blocks	high
tributary stream systems	very high
rare groundwater invertebrates	low
anadromous / semi-anadromous fish	low
wetlands	—
Sources	***Threat rank***
roads / utility corridors	high
residential / commercial / office development	high
cultural resources	high
park facilities / operations / maintenance / use	high
deer browsing	high
invasive / alien species	medium
parasites / pathogens	medium
wastewater treatment	low
overfishing	low
municipal water withdrawals	low
agricultural practices	low
pipeline operations	low

Conservation strategies

At this stage, the SCP process goes beyond the bounds of the I&M program. The SCP next considers actual means of managing the conservation targets in order to sustain their viability. For NPS, this step more properly falls under the parks' larger natural resource management programs.

In general, TNC takes three broad approaches to the development of conservation strategies:

1. *Land and water conservation* includes acquisition of full or partial interest in land or water, as well as on-the-ground management of plants and animals and restoration of habitat.
2. *Public policies* include those at the local level, such as zoning; the regional level, such as the Chesapeake Bay Agreement; and the national level, such as the Endangered Species Act.
3. *Compatible economic development* can range from ecotourism to sustainable forestry, fishing, or other forms of consumptive use that still sustain target viability.

Again, these are ranked according to benefits, feasibility, probability of success, and costs of implementation in order to focus on the most significant.

Development of conservation strategies for the Potomac Gorge is currently underway. Among the many strategies being considered are:

- Cooperative land-use planning with local governments to better protect the tributary stream systems.
- Re-routing park trails to avoid impacts on rare plants in riparian communities.
- Logistical support of regional programs to reduce runoff and siltation from residential and agricultural land that affects anadromous and semi-anadromous fish.
- Exclosures to prevent deer browse impacts on upland forest blocks.

We are presently analyzing the activities of other Potomac Gorge stakeholders to determine where their program goals overlap with our conservation goals so that we can help each other meet mutual objectives.

Measures of success

Success is measured by making progress towards sustaining or enhancing the viability of conservation targets, and towards abating threats to that viability. In the long run, this measurement relies on the development of a monitoring program that concentrates on the size, condition, and landscape context of conservation targets, and on the status of the sources of stresses. This necessitates careful selection of monitoring targets from within each of the conservation targets. The monitoring targets are the equivalent of I&M *indicators*. Monitoring targets under consideration for the Potomac Gorge include:

- Forest interior-dwelling birds in the upland forest blocks.
- Invasive exotic plants in the riparian communities.
- Groundwater quality at the seeps and springs with rare groundwater invertebrates.
- Rare plants in the terrace communities.

However, there is often a lag time between implementation of conservation strategies and abatement of threats, and an even longer lag time between strategy implementation and improvements in target viability. As a result, in the short run success is often measured by increased *capacity* to implement strategies. This capacity-building can take the form of additional staffing, funding, or logistical support. These measures are currently being discussed for the Potomac Gorge.

Conclusion

This project appears to be one of the first times—if not the very first—that TNC and NPS have collaborated so closely on site-based planning. Yet this approach probably could be applied at many places throughout the country where NPS and

TNC have similar interests. We strongly encourage interested parties in both organizations to contact their counterparts to discuss possible cooperative planning.

Acknowledgments

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5 West Nile virus and other fears: opportunities to foster partnerships

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Introduction

Fire Island National Seashore is located off the south shore of Long Island in New York State. The park is the middle 26 miles of the 32-mile-long barrier island. There are 17 communities in the western half and an eight-mile-long designated wilderness (the Otis Pike Fire Island High Dune Wilderness Area) in the eastern half.

The year 2000 marked the third consecutive year that Fire Island National Seashore surveyed the mosquito population in the park. Fire Island, particularly the Otis Pike wilderness area with its vast stretches of salt marsh, is infamous for the large numbers of aggressive mosquitoes that breed (and feed) there in the summer. Although they have been quite limited as disease vectors, the vast majority of people view salt marsh mosquitoes as a nuisance species. Visitors unfamiliar with mosquito biology may be left with the impression that the huge numbers are not only an incredible nuisance but also a fearsome health threat.

The park mosquito management plan calls for collecting data on two species of mosquito primarily: *Culex pipiens* (the common house mosquito) and *Aedes solicitans* (the salt marsh mosquito, with a blunt abdomen). *C. pipiens* is often identified as "PRE," while the *A. solicitans* is often abbreviated to "SOL." SOL was the focus species in a study in the 1980s, which has helped the park with recent emergence of the West Nile virus (WNV) issue. In 1998 and early 1999, studies focused on SOL, with PRE becoming the focus late in the 1999 mosquito season and on to the present. Here, I will be discussing primarily PRE.

The 1980s studies were concentrated in the eastern half of the island and in the adjacent park unit called the William Floyd Estate (WFE). In the park's 1998 mosquito management plan, we used six Centers for Disease Control and Prevention (CDC) light traps in these areas. Pools of 50-100 specimens were tested each week for eastern equine encephalitis (EEE) and all were negative for the disease. This was continued in 1999 and all pools sent for testing were negative. In 1999, toward the end of the program season (June–September), WNV (then thought to be St. Louis encephalitis) was added to the list of potential mosquito-borne diseases that could be found in the New York metropolitan area.

Trapping mosquitoes

The park's mosquito surveillance program is not only designed to find out if EEE or WNV is on Fire Island and to what extent. It is also a good example of integrated pest management, taking into account several factors in the management of mosquitoes in an effort to prevent unnecessarily introducing substances into the environment that may be harmful to humans or other life. In accordance with the park's mandate of preserving natural processes, it is an approach that does not dismiss the right of mosquitoes to exist because they cause discomfort, but acknowledges the mosquito's integral role in natural processes.

Over the summer of 2000, a minimum of nine traps were set out once a week in carefully selected areas of the WFE and from Smith Point to the lighthouse on Fire Island. Traps were generally placed in or close to standing water, with the gravid

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traps placed in freshwater sites. The gravid traps collect only female mosquitoes attempting to lay eggs on the water found in the trap.

Traps were relocated in the same general area if they did not produce at one particular site. In September and October more traps were placed in additional locations on the island. This enabled a more detailed picture of where mosquitoes were most or least active, and the location of any virus present.

Each week ten pools of 50 mosquitoes from park traps were sent in for testing. All proved to be negative for the presence of WNV. Suffolk County Vector Control (SCVC) monitors mosquitoes on Long Island. It set up traps in communities near the park, and in September found one pool of mosquitoes in Saltaire that tested positive. Subsequently, SCVC received permission from the park to aerially spray adjacent park properties with pesticide. The weather soon grew cool enough to reduce the number of airborne mosquitoes to a level where spraying would not have been effective.

Because birds are intermediate hosts for WNV, dead birds found on Fire Island were collected and taken to SCVC for testing (the protocol used for collecting and handling dead birds may be found in the Fire Island mosquito action plan). All were found to be negative for the virus.

Mosquitoes were collected using incandescent light and dry ice as bait for the CDC light traps and an organic liquid as bait for the gravid. This mixture was supplied by SCVC. Six-inch squares of dry ice were hung next to each CDC light trap and the organic liquid was placed in plastic tubs over which the gravid traps were suspended, about 1 inch from the surface of the liquid.

Both kinds of traps operated on the same general principle, consisting of a tube with a fan and a motor, and a net attached at one end. Mosquitoes attracted to the bait were drawn into the tube and then the net by the flow of air produced by the fan. A six-volt sealed lead battery drove the trap's motor.

Trap sites were chosen in consultation with H. Ginsberg (U.S. Geological Survey Biological Resources Division) and the author. For the most part, sites were placed in or near permanent or semi-permanent standing water. Gravid traps were placed in or near freshwater, determined by the presence of ferns, rushes, cattails or other freshwater plants. If a trap placed at one site did not catch mosquitoes within one to three weeks, it was moved to another nearby site. Occasionally traps were moved to be in closer proximity to people. SCVC trapped in one remote area of WFE to conserve collection time.

Trapping was completed once a week from July 17 to October 21. Traps were generally set out in the late afternoon and picked up the next morning as early as possible. Typically, traps were put out on Tuesday, after the dry ice was obtained. If it was raining, traps were set on the next dry day. If it rained all week, traps were set out under umbrellas to protect the gravid trap water from overflowing. Once trapping started for data collection, it was quickly determined that traps should be set out and collected by Thursday afternoon to allow for enough time to sort and count their contents and take them to SCVC by early Friday afternoon.

Trap nets and batteries were collected after approximately ten to twelve hours of operation and the nets put on dry ice until the mosquitoes were sufficiently inactive to remain stationary for the length of time it took to sort and count each pool. Due to the limited number of batteries, and the limited number of connections on the battery charger, it was necessary to charge them up as soon as they came in from the field. In the interest of safety, only a battery charger with a "trickle charge" setting was used. This setting allows the battery to remain on the charger indefinitely until it could be attended to.

With nine (and occasionally ten) trap sites covering the entire length of Fire Island and the WFE, we were under a very tight schedule. So it was decided, after consulting with S. Campbell (SCVC) and Ginsberg, that trap contents should be sorted only into the two vectors: *Culex pipiens-restuans* and *Aedes solicitans*. The total number of mosquitoes in each trap was estimated by a visual method supplied by Ginsberg. Once this was done, groups of approximately 100 to 200 mosquitoes were removed. From these groups, pools of PRE and SOL were obtained in quantities of 10 (minimum pool size) to 50 (maximum pool size). The pools and the remaining mosquitoes were placed in labeled plastic petri dishes and taken to SCVC. From there, they were sent out for testing.

Larval sampling was done on two occasions in 2000: August 14 at the WFE and August 31 at Smith Shores. At the WFE, three larvae were found in the gravid trap freshwater site and one near the light trap in the salt marsh. One larva from the gravid trap site was identified as *Aedes cantator*. No larvae were found at Smith Shores.

Consistently, the greatest number of mosquitoes was found in the light trap at Smith Shores in the Otis Pike wilderness area. At this trap, total numbers of mosquitoes stayed in the four- to five-digit range during the weeks July 31 to October 9, with PRE topping 1,000 in the second to the fourth week of August and again in the middle of September. *Aedes solicitans* remained over 1,000 from the weeks of July 31 to August 28, with a small blip occurring in the week of September 11. None of the traps at the WFE produced in excess of 1,000 (total) mosquitoes.

The number of *A. solicitans* relative to *C. pipiens-restuans* remained high (greater than 3:1) at Smith Shores from July to the end of August. This is in contrast to the WFE, where the ratio remained roughly 1:1 for most of the summer.

In the gravid traps at the WFE and Hospital Point, as in the light traps, the highest number of mosquitoes occurred in the middle of August. As expected, the gravid traps caught egg-bearing *C. pipiens-restuans* almost exclusively, although the numbers were generally well below those in the light traps, never surpassing 100 specimens.

The traps at Watch Hill followed the same general trend as the traps further east, with peak periods occurring during August. Interestingly, the gravid trap at Watch Hill produced the most PRE during the week of July 17, when it was set for the first time.

Numbers in the Watch Hill light trap were estimated to be over 4,000 (total) mosquitoes for the two weeks it was set out, with the number of *C. pipiens-restuans* close to 1,000 for both weeks. The ratio of *C. pipiens-restuans* to *A. solicitans* in the Watch Hill light trap varied, but the number of SOL remained in excess of *C. pipiens-restuans* for both trap weeks.

The Talisman light trap caught only four mosquitoes, even in a week where numbers were slightly up elsewhere. The trap location was moved to a new location in the same general area, but with no significant increase in the number caught. None of the traps west of Watch Hill caught more than about 300 mosquitoes in a trap night. The peak period was, again, the middle of August. The Sunken Forest gravid trap produced the most mosquitoes of any trap in the west in a single night, in the week of August 7, and proved to be more successful than any of the gravid traps in the east.

The Sailors Haven light trap location was changed several times. When it was moved to a new site near standing water it captured about seven times the total number of mosquitoes than in each of the preceding weeks. This trap often had large numbers of non-target mosquitoes, mostly other *Aedes* species. The Sunken Forest light trap was placed in the western end of the forest when WNV was found at Saltaire, a discovery that triggered some discussion about spraying the forest. This trap produced relatively low but significant numbers of *C. pipiens-restuans* in the first two weeks of its operation. The ratio of *C. pipiens-restuans* to *A. solicitans* was generally higher in the western light traps than in the eastern traps on the island, usually roughly 1:2 or 1:1.

The lighthouse gravid trap was the most productive of all the gravid traps used in 2000. It produced over 40 specimens at least half of the time during the peak month of August, and again in mid-September when it was moved closer to the Kismet pond in response to the presence of WNV at Saltaire.

Park actions and suggestions

Each week a report of mosquito numbers and pools was sent to the park headquarters staff. This enabled the park to answer any visitor or constituent questions. The reports demonstrated that the park was taking sufficient action and prevented fears of a WNV outbreak originating in the park.

A park committee made up of representatives from each branch of the staff developed a mosquito action plan (MAP). This had four levels of action: from public education and monitoring to possible spraying for mosquitoes and closing areas of the park if the virus was found. The MAP also contained instructions for bird carcass removal and transport to SCVC for WNV testing. Eight large black plastic trunks were set up with equipment that might be needed if we had advanced through the four levels of action. The four action levels parallel the four levels of mosquito monitoring found in the protocols set up by Ginsberg.

The MAP and mosquito monitoring in 1999 and 2000 enabled the park to collect data on the mosquito population and monitor for any possible WNV. In 2001, the park will again be using the same basic protocols, with education and area sanitation as the first line of defense. As the mosquito numbers increase, the protocols call for increased trapping, larval counts, or both. If a positive pool or infected bird is discovered, the basic action will be increased trapping in that area to identify the degree of threat to the human population. There is also some concern for the effects of WNV on area bird populations. Continued study is underway in this region.

At this time PRE is the primary mosquito found to carry WNV. If others are discovered they will also be collected for testing.

Education remains the first line of defense. The compact disc entitled “Neato Mosquito,” put out by the CDC, is a good reference, along with folders from other governmental health agencies and the park. The park continues to work with its many partners and cooperators to ensure that the best information is made available to the public.

6 Crossing boundaries at Haleakala: addressing invasive species through partnerships

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Increasing "globalization," involving proliferation of pathways for potentially invasive species, poses the ultimate threat to Hawaii's parks, jeopardizing their very survival. This same fear is now being voiced for all biodiversity worldwide (e.g., Mooney and Hobbs 2000; Van Driesche and Van Driesche 2000; Campbell 2001). But oceanic island ecosystems in general and the Hawaiian Islands in particular are especially vulnerable (Loope et al. 2001). Hawaii is an evolutionary showcase, with very high local endemism and many textbook examples of adaptive radiation. We at Haleakala National Park are involved in many excellent partnerships, detailed below, to address invasions, but we are increasingly realizing that Hawaii is overwhelmed—more federal and state resources are desperately needed.

Haleakala National Park, encompassing 44 sq mi, or 6% of the 728-sq-mi island of Maui, Hawaii, is one of the most important reserve sites in the USA for conservation of biodiversity. Stretching from the sea to 10,023 ft above sea level, it is still overwhelmingly dominated by native species. Roughly 90% of its plant and invertebrate species are Hawaiian endemics and 20% are single-island endemics. Conservation International recently included Hawaii in its 25 biodiversity hotspots (Mittermeier et al. 1999), and Haleakala is arguably the prime reserve on Maui. Maui has other important state and private reserves, so that the total area of land managed or soon to be managed for biodiversity conservation approaches 15-20% of the island. We believe that Maui is the most intact Hawaiian island and has the most promise for long-term native species and ecosystem protection.

The two of us have focused much effort outside park boundaries in the past decade, working with partners and partnerships which have promise for improving efforts on Maui and statewide for prevention, detection, rapid response, and containment or biocontrol of invasive alien species.

During the 1980s, Haleakala made major progress in resource protection by erecting 40 mi of boundary fencing and eliminating feral goats *(Capra hircus)* and pigs *(Sus scrofa)*, long recognized as the greatest threats to park resources. A shared experience with a rabbit invasion, in 1990, was very influential in shaping our proactive orientation. An incipient and expanding population of European rabbits *(Oryctolagus cuniculus)* was discovered and removed (100 individuals) over a 10-month period (Loope 1992). Through competently dealing with the rabbit invasion, the park and the island had dodged a bullet—at least temporarily. But we were disturbed to learn that no agency in Hawaii is responsible for preventing rabbits from getting established. The Hawaii Department of Agriculture sheepishly confessed that "our mandate is to encourage rabbit raising." Our eyes and those of others were opened to the serious inadequacy of alien species prevention and response efforts. The rabbit experience brought the vision that long-term protection of park ecosystems is possible if and only if new invasions to the island can be prevented or eradicated. It inspired our confidence in our ability to make a difference—as well as spurring fear of what new invasion might crop up next to threaten the park.

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Our worst fears were answered shortly, when, in January 1991, we first realized the presence and the threat of the notoriously weedy tree, *Miconia calvescens*, which was known to have taken over the island of Tahiti (Meyer 1996; Meyer and Florence 1997). Whereas the rabbit outbreak had fortunately been at a very conspicuous site in the park, *Miconia* was centered five miles from the park, but clearly posed just as great or greater a threat as did rabbits (Medeiros et al. 1997). It soon became evident that partnerships were the only opportunity to deal effectively with such enormous shared threats. Although the ultimate effectiveness of these partnerships remains to be fully demonstrated, we suspect that without them the battle would already be lost.

At the same time, invasive species also pose huge threats to Hawaii's tourism-based economy, agriculture, health, and general quality of life, and the state's residents are beginning to recognize the problem (CGAPS 1996; Holt 1996). The pervasiveness of this issue for society in Hawaii provides hope that it may be possible to marshal adequate resources to address the problem. Each one of the partnerships we describe below has interests beyond the protection of natural areas and biodiversity.

East Maui Watershed Partnership

The East Maui Watershed Partnership (EMWP), established in 1991, has the objective of managing 100,000 acres on windward East Maui to maximize water quality, sustained production of water, and protection of Hawaiian biological diversity. It is composed of federal, state, county, and private entities. Although the partnership members have different mandates, priorities, and constituents, all share a common commitment to the long-term protection of the watershed. Since its formation, the EMWP has successfully constructed miles of feral animal fencing, reduced feral pig numbers, and facilitated control of *Miconia*. This partnership provides a highly successful model for combining biodiversity concerns with concerns for watershed protection, including invasive species prevention and management in Hawaii.

Maui Invasive Species Committee (MISC) / Melastome Action Committee

In 1997, agencies and individuals on the island of Maui that had been working together at a grassroots level for six years to deal with invasion of the weed tree *Miconia* formed an interagency working group, the Maui Invasive Species Committee (MISC), to deal with incipient invaders. MISC partners include Haleakala National Park, U.S. Geological Survey Biological Resources Division (USGS-BRD), U.S. Department of Agriculture (USDA) Tri-Isle Resource Conservation and Development Council, USDA Forest Service, U.S. Fish and Wildlife Service, Hawaii National Guard, University of Hawaii, Hawaii Department of Land and Natural Resources, Hawaii Department of Agriculture (HDOA), Maui County Department of Water Supply, Maui Land & Pineapple Company, The Nature Conservancy of Hawaii (TNCH), and Maui Farm Bureau. Public education and publicizing success stories are crucial ingredients of the anti-invasive species strategy. Maui efforts have inspired motivated individuals to form similar partnerships on other islands.

MISC and its partners have made serious headway to date through surveying, treating, and eradicating the most serious invasive plant species that threaten ecosystems of Maui, including those of Haleakala. Other important conservation lands, including Kanaio National Guard Training Area, Kealia National Wildlife Refuge, TNCH's Waikamoi and Kapunakea Preserves, Maui Land & Pineapple Company's Puu Kukui Preserve, several State Natural Area Preserves, and many other as-yet undesignated natural areas will ultimately be jeopardized unless the invasive plant and animal species being addressed by MISC are contained or eradicated.

An island-wide plan establishes categories (exclusion, eradication, containment, large-scale management) and sets priorities and responsibilities for pest management. In 1999-2000, an action plan was launched (funded by $800,000 raised from federal, state, county, and private sources) against top-priority species. The major species currently being combated are *Miconia calvescens*, pampas grass *(Cortaderia jubata),* fountain grass *(Pennisetum setaceum),* ivy gourd *(Coccinia grandis),* giant reed *(Arundo donax),* and rubber vine *(Cryptostegia grandiflora).*

The role of USGS-BRD has properly evolved from large involvement in education, strategy development, planning, and assisting with fundraising for MISC and the Melastome Action Committee to one of information-gathering and research. We see a major role of the Haleakala Field Station as assessing current and future alien species threats, especially plant problems on Maui. In FY2000 funding was received for a three-year National Park Service NRPP (Natural Resource Preservation Program) project, "Information Gathering and Development of Methodology to Address Newly Emergent Alien Plant Species that Threaten Ecosystems of Haleakala National Park." This project is building on previous work to explore the process of invasion on Maui and obtain baseline data on incipient alien plant invasions that may pose severe threats. It is primarily aimed at recognizing and nipping in the bud new plant invasions by detecting situations where new weeds are starting to spread and alerting the interagency control crew of MISC and the new NPS Hawaii Exotic Plant Management Team. The project is mapping cultivated and escaped populations of 110 plant species identified as warranting concern. It is also exploring the more general question of how an early warning system might work.

Hawaii Ecosystems at Risk Project

The Hawaii Ecosystems at Risk (HEAR) project was started in 1996 as an invasive species information system to serve the needs of land managers and the public. In FY2001, funding was received through the National Biological Information Infrastructure (NBII) to provide base-funding for HEAR, in cooperation with the Bishop Museum and the University of Hawaii, as an invasive species-focused component of a Pacific Basin Information Node (Thomas and Loope 2001). A thrust for FY2001 is to work with Rod Randall in southwestern Australia to get the world's best plant risk assessment database (for species that have invaded other parts of the world) into a format which can be made available on the internet. In Hawaii, we will match Randall's database against a list of plant species cultivated in Hawaii (approximately 13,000 spp.) being developed by George Staples of the Bishop Museum. Unfortunately, as of May 2001 this base funding may have been lost as part of FY2002 budgets cuts.

Na Kumu o Haleakala

Na Kumu o Haleakala is a partnership started by Haleakala National Park interpreters and local teachers in 1996 to produce a Maui-specific environmental education curriculum for local public and private high schools, which will, among other things, educate young people about the threat of alien species on Maui. The partnership is working to produce a comprehensive environmental education curriculum specific to Maui to promote understanding of island ecosystems, a feeling of shared ownership, and a commitment to active stewardship. Na Kumu has completed ecosystem-based modules for Haleakala's eolian zone and rainforest and will soon complete modules for the coastal and marine zones. Plans (and fundraising) are in the works for modules on dryland forest, the subalpine zone, watersheds, and a culminating module on alien species. Each ecosystem-based module has one or more units on the effects and future threats of alien species.

Coordinating Group on Alien Pest Species (CGAPS)

The Honolulu-based Coordinating Group on Alien Pest Species (CGAPS) is an innovative statewide group which has been working since 1995 to coordinate efforts among the many agencies responsible for dealing with invasive species and to improve Hawaii's response to the problem. One possible collaborative strategy calls for attempting to establish a federal quarantine for Hawaii for a wide range of pest species through the USDA Animal and Plant Health Inspection Service, as well as for beefing up the state quarantine with the aid of state funds from airport landing fees or other user fees. (See paper by Reeser, this volume.) CGAPS is also interested in early detection and control of incipient invaders. Holt (1996) stated: "Together with public education, we believe early detection and control of new infestations holds the greatest potential for improved pest management" in Hawaii. Consensus CGAPS priorities for 2001 are as follows:

1. Raise $2 million from the state legislature and private sources to continue and expand funding for the Maui, Big Island, Oahu, and Kauai invasive species committees.
2. Secure $250,000 from the state for *Miconia* biocontrol.
3. Develop a strategy and obtain increased federal assistance to HDOA.
4. Follow-up on the Kahului Airport pest risk assessment to identify the next appropriate actions to improve inspection efforts statewide. Secure $500,000 in discretionary funds for HDOA to continue and expand statewide inspection and quarantine efforts.
5. Significantly increase the level of education and awareness among the legislature and the public regarding the negative impact of invasive species on Hawaii's economy, environment, health, and lifestyle.
6. Enhance HDOA's enforcement capacity.

Hawaii Ant Group and the red imported fire ant

In September 1999, a Hawaii Ant Group was established, comprising scientists from USGS, HDOA, University of Hawaii, and the Bishop Museum. After the red imported fire ant *(Solenopsis invicta)* was first detected in southern California in November 1998, it was realized that invasion of Hawaii is just a matter of time unless heroic prevention, detection, and rapid response efforts are initiated, since huge quantities of goods are shipped to Hawaii from California. Haleakala National Park and its USGS Field Station have been involved for some years in studies of the slowly spreading but destructive Argentine ant (Cole et al. 1992) in an effort to prevent its further invasion of Haleakala's otherwise ant-free high-elevation environment. If the red imported fire ant gets established in Hawaii, its winged queens will quickly spread statewide and very likely invade Haleakala Crater.

Dispersed primarily through human commerce, the red imported fire ant has invaded over 300 million acres in the southern USA in spite of a USDA federal quarantine. It is a serious threat to public health and safety, industry, biodiversity, water quality, economy, and quality of life. Its aggressive nature and powerful sting have caused the deaths of at least 83 people, injury to tens of thousands of people annually, and injury to and death of wildlife, livestock, and pets. Its broad diet, which includes plants and animals, has caused substantial agricultural damage and serious declines in biodiversity (Wojcek et al. 2001). If this ant is allowed to become established in Hawaii, biodiversity impacts can be expected to be particularly severe, since the Hawaiian biota evolved in the absence of native ants and is consequently extremely vulnerable to aggressive ants (Gillespie and Reimer 1993).

Conclusions

The problem of invasive alien species is becoming increasingly recognized as an important issue nationwide and worldwide, but the Hawaiian Islands comprise what is arguably the world's most vulnerable site. Recently published books (Devine 1998; Van Driesche and Van Driesche 2000) zero in on Hawaii's severe problem of continuing invasions, while recognizing that the best hope for improving the situation resides on the island of Maui. In many ways, Hawaii is a model system for dealing with biological invasions, but there is definitely a downside. Financial resources to meet the needs are not proving to be available on a sustained basis. Hawaii was recently beset by a teachers' strike, and although numerous alien species bills were introduced in the 2001 Hawaii State Legislature, most have failed. Extremely important federal resources are at stake in Hawaii—including several superb national parks and more than 300 endangered species. Good opportunities exist on Maui to protect areas such as Haleakala's Kipahulu Valley, arguably the most biologically diverse and intact tropical rainforest ecosystem in the USA.

We contend that Hawaii is a magnificent testing ground for strategies to deal with biological invasions. U.S. mainland ecosystems, given unabated action of similar forces responsible for continuing degradation—habitat destruction, habitat fragmentation, biological invasion, and cascading effects toward biodiversity loss—will be showing comparable symptoms by the second half of this century. Because of the profound human element in biological invasions, effective intervention will necessarily involve catalyzing changes in human behavior. We are confident that we are on the right track in investing much time and effort in partnerships targeted for dealing with invasive species. Support by state and local governments is crucial to success of this endeavor. But we can also see that much more federal support is warranted and absolutely necessary to allow these partnerships a chance to attain their goals.

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7 Getting to the bottom of things at Crater Lake National Park

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Crater Lake National Park is located in southwestern Oregon on the divide of the Cascade Mountains. It lies in an area with a long history of volcanic and glacial activity, extending from Lassen Peak in northern California northward into Canada.

In the middle of the park is Crater Lake, which formed about 7,700 years ago after the climatic eruption of Mount Mazama. The lake occupies the collapsed caldera of the mountain. The lake is 7 to 9.5 km (4.5 to 6 mi) across, has 32 km (20 mi) of shoreline, a surface area of 5,339 ha (13,192 acres), and a depth of 597 m (1,958 ft) at its deepest point, making it the deepest lake in the USA. Annually, about 500,000 visitors come to see the famous deep blue lake.

Early scientists were not content to merely gaze at the sublime beauty of the lake. They longed to know what lay beneath. In 1886, the Dutton expedition, made up of scientists from the U.S. Geological Survey (USGS), came to Crater Lake to take the first-ever measurements of its depth at various locations. In a rowboat dubbed the "Cleetwood," using a lead-weighted spool of piano wire with leather tabs attached to record depth, they took about 100 measurements and recorded a maximum depth of 1,996 ft (Dutton 1886).

Others followed and, in 1956, the USGS used echo sounding to map the lake bottom based on about 5,000 measurements (Byrne 1962). Until recently, that map (Figure 7.1) formed the basis for understanding the geomorphology of the lake's bottom. Their map identified three distinct deep basins. They identified a platform formed by the eruption of Wizard Island. They discovered the submerged Merriam cone and they measured the deepest point at 1,932 ft. More detail of the geologic features would have to wait for technology to progress to the point of getting the additional precision that managers and scientists wanted. Furthermore, significant funding would be needed to attempt such a project. For some time this project remained just another "nice to do" item documented in the park's resource management plan. However, two subsequent unrelated events provided an opportunity to move forward on this project.

On September 23, 1995, a tragic accident happened in the park. A corporate helicopter flew into the park and down into the Crater Lake caldera. The aircraft crested the caldera rim anywhere from 700-2,000 feet above the surface of Crater Lake. According to eyewitness accounts, the aircraft circled near Wizard Island at approximately 350 ft above the lake level and then flew in a southeasterly direction toward the Crater Lake Lodge. The aircraft slowly descended while it flew toward the Crater Lake Lodge until it hit the lake surface, tumbled, broke up and sank quickly in approximately 1,500 ft of water. The pilot and passenger died in the accident.

A fuel slick was observed on the surface of the lake from approximately 70 gallons of liberated jet fuel on board the aircraft. Other solid waste (Styrofoam and floating aircraft debris) was collected from the lake for about a week after the accident. A limited amount of other lubricants such as transmission fluids and engine oils may have been liberated or may still be encased in the wreckage that sank.

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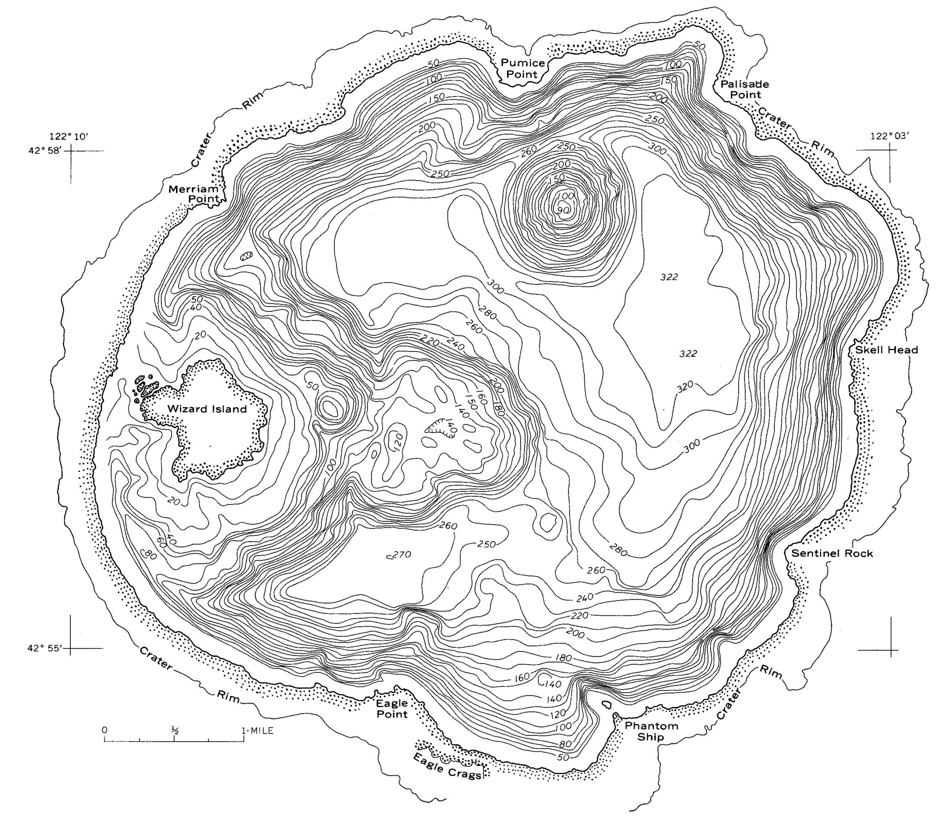

Map of the floor of Crater Lake. Made by U.S. Coast and Geodetic Survey; contoured by Dr. John V. Byrne. Contour interval: 10 fathoms.

Figure 7.1. Map of the floor of Crater Lake. U.S. Coast and Geodetic Survey, 1959.

The park staff had a dilemma. What do you do about helicopter wreckage in 1,500 feet of water? Title 36 Code of Federal Regulations Section 2.17 offered some guidance:

> c(1) ...the owners of a downed aircraft shall remove the aircraft and all component parts thereof in accordance with procedures established by the superintendent. In establishing removal procedures, the superintendent is authorized to: (i) Establish a reasonable date by which aircraft removal operations must be complete; (ii) determine times and means of access to and from the downed aircraft; and (iii) specify the manner or method of removal.

> c(3) The superintendent may waive the requirements of paragraph (c)(1) of this section or prohibit the removal of downed aircraft, upon a determination that: (i) The removal of downed aircraft would constitute an unacceptable risk to human life; or (ii) the removal of a downed aircraft would result in extensive resource damage; or (iii) the removal of a downed aircraft is impractical or impossible.

The Crater Lake superintendent elected to require the helicopter company to conduct a feasibility analysis to salvage the wreckage. It estimated that the cost of salvage would exceed $1 million. Its analyses found that such a salvage operation would be impractical and too risky, and would further damage park resources (Irvin 1996).

Although park managers did not concur in all of the company's findings, the park superintendent decided that present understanding did not support a conclusion that an acute or chronic environmental problem was posed by the aircraft wreckage. The ongoing impact to the lake was primarily one of the aesthetic damage due to the wreckage. Park managers agreed that the benefits associated with recovery did not outweigh the risks.

Nevertheless, it seemed wrong to absolve the company from any responsibility for the damage to the park's natural resources. Park managers believed that the company should somehow be held accountable for damage to the park, even if it was accidental. Consultation with the National Park Service (NPS) Environmental Response, Planning and Assessment Division suggested a possible remedy through a recently passed act.

In 1990 Congress passed the Park System Resource Protection Act (P.L. 101-337, 16 USC 19jj). The law allows NPS to seek compensation for damages and to retain those monies, without further appropriation, to restore, replace, or acquire equivalent resources. Under the statute, NPS can also collect any costs associated with responding to and assessing the damages related to such incidents, including monitoring. Money recovered as past costs or for future assessment or restoration work are placed in an investment account that earns interest until used.

The Resource Protection Act is a tool for protecting and restoring park resources. It is not a regulatory tool. It is compensatory, not punitive. The goal of the law is to restore damage and make the park whole, not to punish. However, the law is also a strict liability law that means a manager does not need to demonstrate negligence but only that damage occurred from an action of another party.

A second event happened in the summer of 1998. Secretary of the Interior Bruce Babbitt visited Crater Lake and discussed our ongoing lake research program. Babbitt informed the park of a research project to map the bottom of Lake Tahoe that USGS had completed using a new multibeam sonar system. The system was highly precise and produced a high-resolution map (Gardner et al. 1998). The contact spawned interest by the USGS to conduct a similar survey at Crater Lake; however, there was no funding for the project.

From these events, park managers began to see a way that we could partner with the USGS and the Department of the Interior Solicitor's Office to acquire the technology and the funds to search for the helicopter and assess the crash site and simultaneously map the lake bottom.

The civil case took some time. The helicopter crashed in 1995 and the Solicitor's Office successfully settled the case in 1999. We started the project in the summer of 2000.

NPS transferred funding to USGS to conduct the project by means of an interagency agreement. USGS in turn used a cooperative agreement it had established with the University of New Hampshire to acquire the professional expertise and engage a contractor from Louisiana who owned the sonar technology. The research vessel and sonar equipment were trucked to Crater Lake to begin the project.

Access to the lake surface is limited to a foot trail. Park managers obtained approval from the Pentagon and enlisted the services of the U.S. Army Reserves from Fort Lewis, Washington, to transport the research vessel 1,000 feet from the caldera rim to the lake surface. Once there, it took only five days to complete the search for the helicopter crash site and survey of the lake bottom.

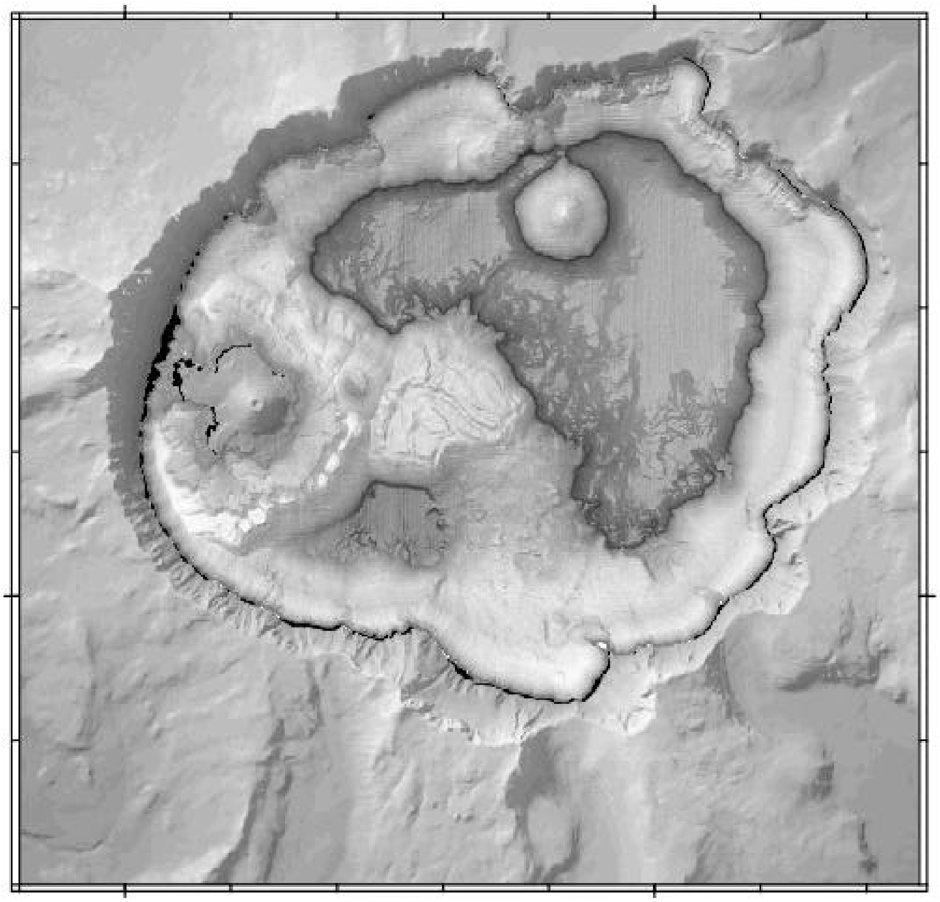

Figure 7.2. Preliminary bathymetric image of Crater Lake. U.S. Geological Survey, 2000.

This project attracted significant media attention. Park managers used the opportunity to promote the project. The project's discoveries were shared through a media campaign that focused on the technology and the scientific contributions of the survey. Throughout the period of the survey park staff made 74 media contacts. As a result, the project was covered repeatedly on television, radio, and newspapers throughout the NPS Pacific West Region as well as in newspapers in the Rocky Mountains and Midwest. The park's message was delivered to over a million individuals, based on the reported viewing audiences of and subscribers to those local stations and newspapers which ran spots and articles on the events of the survey. This is analogous to reaching twice the park's annual visiting public with a very focused message of "parks as laboratories."

Even though we did not locate the helicopter itself, the survey of the lake bottom was extremely worthwhile. The new images revealed incredible details of ancient lava flows, huge landslide debris fields, newly discovered vents, ancient lakeshores, and other fascinating geologic features (Figure 7.2). Park managers anticipate that the information from these new data will launch the park into a new era of scientific investigations about the lake and its volcanic origins.

Although the survey phase of this project is now complete, the park will continue to reap the benefits of this research for years, if not decades, to come. In the near future these data will be made available to interested scientists. The park's Natural History Association is interested in obtaining the final map and brochure from the data as a future sales item. And in addition to providing the map data, USGS is interested in a future partnership to provide data and software to establish an interactive interpretive display for the park's visitor center. The display will allow the visiting public to "explore" the bottom of Crater Lake electronically.

Lessons learned

There are several lessons that park managers learned through this process that will help prepare for future partnership opportunities.

1. Know what you need and write your needs down. It is important to take a broad and long look at what your park needs to manage its resources. There is value in developing and updating your resource management plans.
2. Market your program. Communicate your needs widely. To your superiors, your peers, other agencies, non-profits—to anyone who will listen. We need to do a better job of marketing what we are trying to do in resource management and actively solicit support from potential partners.
3. Network. Get to know a wide variety of folks who may help you out one day. And not just in your discipline—the majority of key players in this case study were not scientists or resource managers. They included attorneys from the Solicitor's Office, NPS Washington Office support personnel, public information officers, military contacts, and agency program managers.
4. Be creative in meeting your needs. (Think outside the box.)
5. Don't give up. Be persistent but be patient. (The rules were written for the box.)
6. Be prepared to seize or create opportunities.
7. Success leads to success. Use your successes to build credibility and momentum, and to develop new opportunities with new partners.

Conclusion

Born out of a civil settlement initiated five years ago, this project grew from an unlikely compact between attorneys, corporate executives, insurance adjusters, government officials, and research scientists. These results demonstrate that with perseverance, determination, shared vision, and a noble goal, we can accomplish extraordinary things.

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8 Partnerships for management of noise intrusions

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The National Parks Air Tour Management Act of 2000 (Title VIII of P.L. 106-181) requires, among other things, the U.S. Federal Aviation Administration (USFAA) and the U.S. National Park Service (USNPS) to jointly develop air tour management plans (ATMPs) for all U.S. national parks with commercial sightseeing air tour operations. Military overflights occur at over 100 U.S. national parks, and a number of other noise sources impact park soundscapes. The USNPS Soundscapes Program Center was established in October 2000 to work with the USFAA, military, and other organizations to mitigate noise intrusions and address park soundscapes issues in units of the National Park System. The following discussion presents the overall organization and approach of the USNPS Soundscapes Program Center, some of the major issues the center is addressing, and efforts to enhance the partnerships between the various agencies and interests involved.

Soundscapes Program Center

Natural sounds are an integral part of the resources and values in parks that USNPS is charged by law to preserve unimpaired. Natural sounds are also an inseparable part of what visitors come to national parks to enjoy.

Countless visitors have thrilled to a wolf howl, an elk bugle, Old Faithful in full eruption, or a waterfall on a large river. Few things are more pleasant and soothing than the melodious call of a canyon wren, water bubbling in a small creek, the soughing of wind through the pine forests and aspens, or a chorus of bullfrogs in early evening. The full complement of such sounds can provide superintendents with an indicator of the health of the park ecosystems.

Sounds such as these have, until recent years, been largely taken for granted by both the visiting and interested public and park managers and staff. Intruding noise from such sources as aircraft, cars, buses, snowmobiles, personal watercraft, all-terrain vehicles, etc., was, until 25 years ago, generally minimal in both numbers of events and loudness. With the increase in visitation to parks, from about 190 million in 1975 to 429 million in 2000, both the numbers and loudness of noise events have increased dramatically. In many parks such noise adversely affects the natural soundscape and wildlife, as well as visitors' opportunities to hear natural sounds and to experience solitude and tranquility. Visitor complaints in some parks are increasing. In a few isolated cases, individual parks have addressed noise intrusions: watercraft noise effects on humpback whales at Glacier Bay, outboard motor noise on commercial-river rafts at Grand Canyon, management of snowmobiles in a few parks, negotiations with the military on flight routes in a few parks, and so on. On a Servicewide basis, with the exception of air tour overflights at Grand Canyon, only a few of the more intrusive noise issues have been addressed. Those include establishment of a

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general regulation on audio disturbances (addressing campground intrusions), snowmobile noise limits, boating noise limits and a mention of noise in the disorderly conduct regulation (all in Title 36 of the U.S. Code of Federal Regulations). There are also noise restrictions on buses. Only recently has USNPS officially identified soundscapes as a natural resource and initiated development of a comprehensive soundscapes management program.

Within the past decade or so there has been growing attention to soundscapes, which has resulted in congressional passage of P.L. 100-91 (the National Parks Overflights Act of 1987) to manage air tours over Grand Canyon and the National Parks Air Tour Management Act of 2000 to manage air tours over other parks. In the National Park Service Management Policies (e.g., Section 4.9) and the NPS Director's Order 47, natural soundscapes are clearly identified as a natural resource to be protected, and direction is given to park managers to incorporate protection and management of soundscapes into their management programs equal to other park resources and values.

To address these directions, USNPS established a Soundscapes Program Center in late 2000 at Fort Collins, Colorado. The purpose of the center is to provide support and assistance to parks to address soundscapes issues. The primary emphasis for the next several years will be to assist those parks that will need to accomplish ATMPs under the Air Tour Management Act of 2000. The act directs that USNPS work cooperatively with USFAA to prepare ATMPs. Additionally, the Soundscapes Program Center will assist parks in gathering baseline acoustic natural ambient data to characterize their soundscapes and record intrusive noise. The center will also assist parks with other noise issues, including the preparation of soundscapes management plans, military overflights, snowmobiles, personal watercraft, airport noise, and park operational noise (aircraft, heavy equipment, etc.).

In summary, noise created by ever-increasing types and numbers of modern technology, vehicles, and equipment is progressively adversely affecting natural and cultural resources and the quality of visitor experiences in national parks. Congress has given recent direction to address air tours over national parks and USNPS is addressing this by having established policies and directions to protect the natural soundscapes in parks and a branch of the Washington Office to assist parks in those protective efforts.

Soundscape issues

Impact assessment and mitigation. To assess impacts on natural soundscapes, one must cross many scientific, policy, management, and institutional barriers. Difficult questions must be answered. For example, what data are needed to characterize park soundscapes? Is there a single metric that provides enough information? How many soundscapes does a park have, and what criteria separate one soundscape from another? What constitutes a significant impact on a park soundscape? What are the mandates and processes, and who are the players needed to make these decisions? A number of approaches have been used by scientists to assess noise impacts on various environments and populations. However, research has shown that many of the traditional methods and metrics are not applicable in national park environments. USNPS is working with experts in many scientific fields, involved agencies and organizations, interest groups, and the general public to develop policies and guidance to assess and monitor noise impacts on park resources and visitors in the most accurate, efficient, and scientifically supportable manner.

At Grand Canyon, for example, a major study is underway to compare the aircraft noise levels calculated by several aviation noise models with data measured simultaneously at many sites in the field. Mitigation measures such as flight routes, flight-free zones, timing, and numbers of flights are necessarily assessed in large part by using such models. The equipment and methodology for gathering the acoustic data needed for the models and other impact assessment and monitoring are being updated and improved in efforts involving multiple agencies and experts, but not without some difficulties involving differences in the policies, mandates, and interests of the various parties.

Interpretation and education. Educational efforts are increasingly important in leading to an accurate understanding of park soundscape issues so that meaningful dialogue can take place leading toward issue resolution. While considerable interest has been evident in the U.S. national media regarding park soundscape issues such as air tour overflights, snowmobiles, and personal watercraft, an alarming amount of such information has been less than completely accurate concerning USNPS concerns, mandates, and actions. In a number of cases, the media has contributed to misunderstanding and confusion among many parties. One of the major efforts to address this problem is development by USNPS of a package of tools for interpreters, educators, and managers called “The Nature of Sound.” The package consists of an education plan, articles and papers on all sides of the issue, references, brochures, and interpretive tools such as a slide program, electronic files, and an audio tape. The materials can be customized for specific purposes at specific parks. Major themes include: national parks are special places; national parks have many special requirements, such as preserving resources and values in an unimpaired condition; national parks have many special opportunities, often including those for solitude, tranquility, and experiencing the sounds of nature; the natural soundscape is an important resource in many parks; USNPS uses aircraft and other noise sources for essential management purposes; and USNPS preserves and celebrates the history of powered flight in units such as Wright Brothers, Dayton Aviation, and Tuskegee Airmen.

Non-aviation sound issues. Much of the effort of USNPS has been focused on defining or clarifying policies and methodologies, and then applying them to aviation noise sources. However, other noise sources are also important. As previously mentioned, issues involving snowmobiles and personal watercraft have been the most obvious. Other non-aviation sound issues in parks include: transportation means, such as automobiles, trucks, buses, and trains; USNPS equipment use, such as heavy machinery, chainsaws, and other tools, as well as vehicles; electrical generators; audio devices; and events such as concerts and speeches.

Cooperative efforts of USNPS and USFAA

To enhance cooperation and understanding between USNPS and USFAA, several actions were initiated. First, each agency designated a liaison to be a point of contact. Marv Jensen, manager of the Soundscapes Program Center, is the designated person representing USNPS. His counterpart in the USFAA is Barry Brayer, the leader of the effort to develop ATMPs. The agency liaisons communicate on a regular basis. As a result, they have developed a trusting relationship and understanding of the respective agency’s missions, policies, and positions. Second, both agencies have worked together to ensure that the language in the USFAA draft regulation to implement the National Parks Air Tour Management Act of 2000 accurately reflects each agency’s position. As a result, several contentious issues have been eliminated prior to the draft rule being submitted for public review and comment. Third, an implementation plan was jointly crafted by both agencies. The plan describes the joint organizational structure, procedures, and roles and responsibilities that will be utilized in the development of the ATMPs. The plan also presents a dispute resolution mechanism, joint funding approach, and detailed outline of the ATMP planning process and contents. Finally, the specifics of the implementation plan have been formalized in a draft interagency agreement that will be signed by senior management of each agency. Although the actions initiated will not alleviate all conflicts and misunderstandings between the agencies, it has significantly enhanced the partnership and has laid the groundwork for a less contentious relationship.

Partnerships on military overflight issues

The U.S. Air Force (USAF) and other Department of Defense entities need ranges and airspace to train pilots and weapons and conduct other military operations. Because most of the population of the USA lives east of the Mississippi River and airspace there is extremely congested, many of the military training and operations flights take place over the western USA, where most federal lands are located. Military overflights, whether high and fast, low and slow, in any combination, can have adverse impacts on park natural and cultural resources and visitor experiences. Surveys of park managers have consistently identified at least 100 parks with actual or potential concerns about military overflight issues. Maps prepared for USNPS by USAF's Ranges and Airspace Office support those perceptions, graphically depicting the very high percentage of military training routes and military operations areas that lie over or within 10 miles of national park units. In many cases, congressional designation of military ranges and special use airspace predates the designation of park units, meaning that the military services have a statutory right to fly there.

To enhance cooperation and understanding between the two agencies, USNPS has become a regular and active participant in the six USAF Regional Airspace/Range Council meetings that are held around the country each year. USAF and USNPS have developed a relationship of trust which has led to the prevention or mitigation of adverse impacts at a number of parks, including Big Bend, Biscayne, Everglades, Joshua Tree, Pipe Spring, and Sequoia-Kings Canyon. A number of these agreements were negotiated between individual base commanders and park superintendents. In some instances these agreements were never documented, causing potential confusion when those officials were transferred. The next logical step is for the two agencies to formalize their relationship, which they intend to do by jointly developing regional communication guidebooks. Each guidebook will depict airbase locations, military training routes, military operations areas, and units of the National Park System. The guidebooks will also present each agency's organizational structure, decision-making process, and points of contact, as well as ways to enhance communications and develop relationships between base commanders and park superintendents. Both agencies intend that this concept be extended to other military services and land management agencies in the near future.

References and supporting information for this paper are available from the authors upon request.

9 Remotely sensed burn severity mapping

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Introduction

With nearly a century-long national policy of fire suppression, many of our nation's forests have an unnaturally heavy accumulation of brushy ground fuels and dense young trees. These "ladder fuels" provide the connection between *low-intensity* ground fires and *high-intensity* crown fires.

In 2000, almost 7 million acres burned across the USA. The extraordinary number, size, and, in some cases, severity of these fires was due to drought conditions, weather patterns, and a large number of lightning strikes. Compared with the previous ten-year average, more than twice the number of acres were consumed. Such fire activity is inconsistent with the National Park Service (NPS) mission "to preserve and to protect," and the NPS Fire Management Program focus of "restoring and maintaining natural processes associated with fire." The NPS fire management program includes hazardous fuels reduction, prescribed fire, wildland fire for resource benefits, and wildland fire suppression (Gale 2000).

All of the fire preconditions referred to above were present at the Grand Canyon in 2000. A prescribed fire "blacklining" operation in the Outlet Prescribed Fire Unit encountered unexpected high winds on May 9, which caused the fire to "spot" outside the unit. The resulting fire consumed more than 13,000 acres, burning through several forest types and fuel model classes, at varying intensities. Having burned off the North Rim and into inaccessible canyonlands, the Outlet Fire was in suppression mode until fully controlled on August 30, and was declared completely out on November 14.

Objective

Robert Stanton, director of NPS, specified that the agency's fire programs are to "scientifically manage wildland fire using best available technology as an essential ecological process to restore, preserve, or maintain ecosystems…" (Stanton 1998). In a joint report to the president in response to the wildfires of 2000, one of the key recommendations made by the secretaries of Interior and Agriculture was that damaged landscapes be restored and communities rebuilt (Babbitt and Glickman 2000). Immediately following wildfire control, that process is implemented and recorded in a burned area emergency rehabilitation report. Stabilization and restoration are facilitated by a spatial understanding of fire severity. Recognizing this, the 1998 Joint Fire Science Plan encouraged research that develops "airborne and satellite-based remote sensing applications, for quantifying ... fire effects such as ... fire distribution and severity" (Botti and Saveland 2001).

It is the objective of Grand Canyon National Park's Fire Management Program and its Science Center GIS Lab to support these national recommendations. Towards that end, we have implemented a fire severity mapping procedure that accurately and cost-effectively measures fire severity, and that can be done with computer

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software and hardware common to most national park Geographic Information System (GIS) departments.

Methods

Traditional methods of recording burn severity involve traversing the interior of the fire by foot or observing it from an airborne platform, and then mapping (by hand) resource damage into predetermined classes. The burn severity coding matrix, with severity fields ranging from unburned to heavily burned, and records of substrate and vegetation, was modified to four simple classes (unburned, low severity, moderate severity, or high severity), incorporating substrate and vegetation concerns, as detectable from an aerial view (Botti et al. 1992).

Where fire size and time permit, this method provides satisfactory results. As fire sizes increase, and time becomes a constraining factor, traditional methods become costly and labor-intensive to the point where accurate mapping of severity classifications is precluded.

For the Outlet Fire, a visual estimation from a helicopter provided the first measure of fire severity. Within an hour, the park's fire ecologist visually estimated and mapped fire severity into four classifications. The classes were drawn in the field onto a 15-minute U.S. Geological Survey (USGS) topographic quadrangle map (Figure 9.1). In view of the time and cost constraints, this was an effective but difficult mapping exercise, at a charged rate of approximately $2,500 per hour for helicopter use alone.

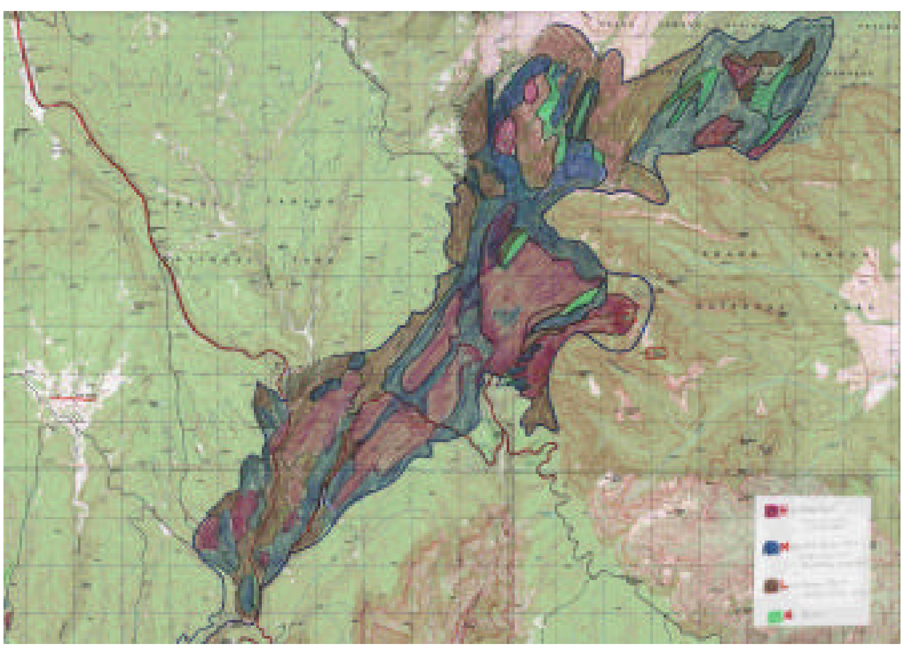

Figure 9.1. Hand-drawn fire severity map of Outlet Fire, 2000.

Airborne- and satellite-based remote sensing platforms are uniquely suited for large landscape assessments. Satellite-based platforms have recently become increasingly cost-effective, through recent efforts by the National Aeronautic and Space Administration (NASA), USGS, and NPS to make satellite imagery more available.

Prices for current radiometrically and geometrically corrected imagery range from about $600 for Landsat 7 imagery (Level 1G), to $1,500 (at Level 2A) for SPOT 4 imagery. Terrain-corrected Landsat 7 imagery costs $900 (at pricing specifically for federal agencies).

For purposes of comparison, Landsat 7, SPOT 4, and Ikonos satellite scenes were requested for dates as close as possible to the beginning and end of the Outlet Fire. Image pre-processing appropriate to capabilities expected of NPS GIS departments was requested, i.e., scenes that had been radiometrically corrected, geometrically corrected, and ortho-rectified (terrain-corrected). The Landsat 7 scenes we received were fully pre-processed, while the SPOT 4 scenes were radiometrically and geometrically corrected but not ortho-rectified. For comparison purposes, we ortho-rectified the SPOT 4 scenes in ERDAS Imagine (Figure 9.2). Unfortunately, we were unable to obtain Ikonos scenes in time for this comparison.

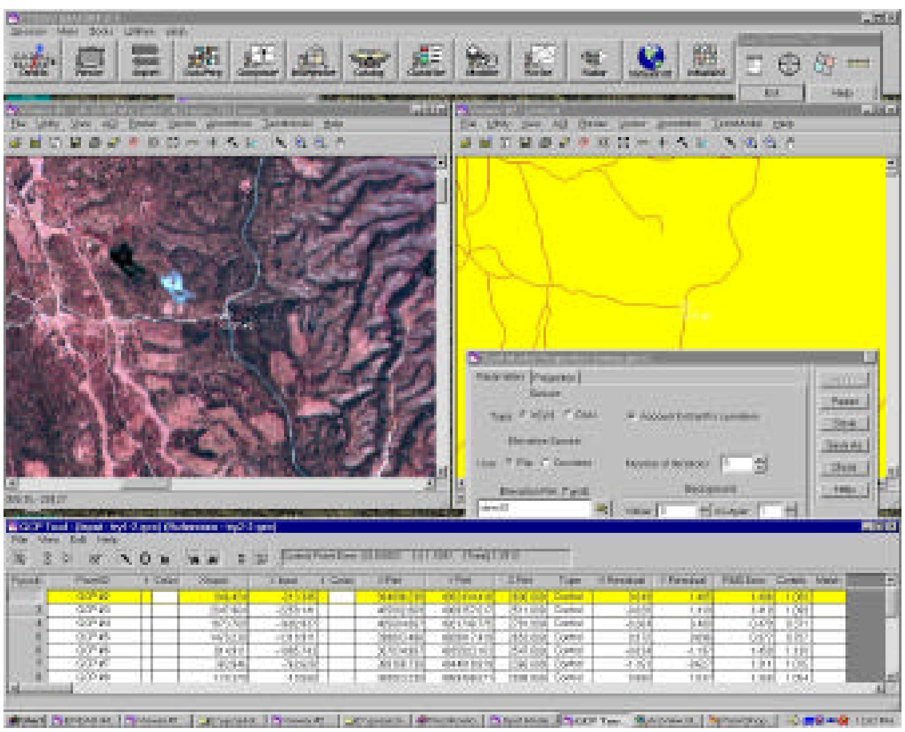

Figure 9.2. Ortho-rectification of SPOT 4 imagery, using ERDAS software.

Remote sensing techniques

With digital imagery, advantages in analysis are first seen in the opportunity to perform mathematical operations on the image, some simple, and some involving complex sequences of formulas.

One of the simpler operations performed is *change detection*, where the pixel values of one scene are subtracted from the corresponding pixel value of a later one. Seasonal variations in vegetation are sufficiently different that they may be easily detected by change detection. In the case of the Outlet Fire, which started in early May, the vegetation of the area had already leafed out. From SPOT 4, we received satisfactory image scenes dated June 10, 1999, and September 25, 2000. From

NASA–USGS, we received Landsat 7 image scenes dated May 5, 2000, and June 6, 2000. The Landsat 7 scenes were nearly ideal for purposes of change detection, with image capture taking place just days before the Outlet Fire started and then after nearly 95% of the fire had burned.

Another remote sensing method, using a more complex mathematical operation, is referred to as *image classification.* One image classification technique is referred to as *iso-clustering*, where clusters of similar pixels are placed into separate classes. What the human eye can discern comparing one image to another, iso-clustering does mathematically, with multiple image sets. For our purposes, we chose iso-clustering classification for an independent comparison.

Landsat 7 and SPOT 4 are functionally similar, but differ in the spectral and spatial resolution of their images. Landsat 7 (the seventh generation of Landsat spacecraft) and SPOT 4 (the fourth generation of SPOT spacecraft) employ a different number of spectral bands receiving similar but different spectral ranges, at differing resolutions (Table 9.1).

Landsat 7			***SPOT 4***		
Band number	*Spectral range (microns)*	*Resolution (meters)*	*Band number*	*Spectral range (microns)*	*Resolution (meters)*
1	0.45-0.515	30	1	0.50-0.59	20
2	0.525-0.605	30	2	0.61-0.68	20
3	0.63-0.690	30	3	0.79-0.89	20
4	0.75-0.90	30	4	1.58-1.75	20
5	1.55-1.75	30	Pan	0.61-0.68	10
6	10.40-12.5	60			
7	2.09-2.35	30			
Pan	0.52-0.90	15			

Table 9.1. Comparison of spectral and spatial resolution: Landsat 7 and SPOT 4.

Landsat 7 and SPOT 4 images underwent the same image processing. All spectral bands, and all combinations of spectral bands, were inspected visually for image quality and analyzed for sensitivity to fire effect.

For Landsat 7, bands 2, 4, 5, and 7 selected spectral ranges that were particularly effective in capturing signatures of vegetation moisture stress analysis, vegetation turgidity, amount of vegetation biomass, and the green reflectance of healthy vegetation, respectively. With SPOT 4, bands 1, 2, 3, and 4 approximated Landsat 7 bands 2, 3, 4, and 5, respectively, with approximately the same spectral ranges (a slight 0.02- to 0.04-micron shift to right) and signature selectivity. For purposes of comparison, before and after Landsat 7 and SPOT 4 image pairs underwent exactly the same level of image analysis routine. Each pair:

- Was inspected, band-by-band, for perceived differences in the pre- and post-fire images;
- Underwent change detection;

- Underwent an unsupervised classification, initially with all bands, then with three bands, selected for classification sensitivity; and
- Underwent NDVI (normalized difference vegetation indexing), a remote sensing technique commonly used where vegetation is the primary reflectance object. NDVI is calculated from the reflected solar radiation in the near-infrared (NIR) and red wavelength (RED) bands via the algorithm: NDVI = (NIR – RED) / (NIR + RED). For SPOT 4, the NIR is band 3 and the RED is band 2. For Landsat 7, the NIR is band 4 and the RED is band 3.

Landsat image pairs underwent a recently introduced remote sensing technique, NBR (normalized [differencing] burn ratio), which is similar to NDVI (Key and Benson 1999). The NBR technique relies on the use of Landsat 7 band 4 and band 7, spectral ranges not available in SPOT 4.

Results

Visual comparisons were made of each band, each band combination, each band combination classification, and the successive normalizations. Random point reflectance value correlations were made between, and within, the above comparisons. All bands of both satellite platforms were capable of detecting change between the start and end of the fire. A small amount of change was detectable outside the Outlet Fire perimeter, but was limited to areas off of the North Rim. This was presumably due to the differences in the before and after sun angles, inducing different ground shadowing in a more sparse pinyon–juniper forest type, descending into a desert scrub community. Band combinations with the greatest differences (widest reflectance value amplitude) between images were viewed to be most sensitive in detecting change.

SPOT. SPOT 4 sensors were the most specific (detecting the narrowest spectral ranges), and change detection routines across individual bands were effective, but particularly so with the combination of bands 4, 2, and 1. Unsupervised classifications were also effective, with the 4-2-1 composite being the most so. Band 3 was ineffective in detecting the changes induced by fire across the vegetative surface offered by the Grand Canyon's North Rim forests. Performing a NDVI operation on reflectance values (B3-B4 / B3+B4) yielded the widest amplitude (Figure 9.3).

Landsat. Change detection routines across each of Landsat 7's seven band combinations were similarly effective in demonstrating change, but were most successful in bands 7, 5, and 4. Unsupervised classifications were effective, with greater sensitivity found in the combination of bands 7, 5, and 4. An NDVI operation was performed on Landsat 7 bands 4 and 3, and bands 5 and 3 (to compare both NIR bands). Visual findings supported the literature on vegetative indexing optimization with band 4 and band 3 normalization. An NBR operation was performed on Landsat 7's bands 7 and 4, yielding one of the wider ranges of reflectance value amplitude differences. The greatest sensitivity to differences in reflectance values was found in a change detection operation on the NBR performed on before and after Landsat 7 images (Figure 9.4). SPOT and Landsat image differencing from selected bands, selected band combinations, and indexed band combinations all yielded more change-sensitive estimations of fire severity than did visual estimation from a helicopter.

Discussion

Grand Canyon National Park's entry into remote sensing was initially seen as a way of supporting fire effects monitoring of prescribed fire management. This was to involve a consistent annual selection of image capture dates. Those national parks which keep annual records of the date of vegetation "green-up" will have an advantage in being able to predict a "window of opportunity." (Coincidentally, the Outlet Fire occurred within our time frame being considered for yearly monitoring.) Shifting to "short-term monitoring," satellite imagery (Landsat 7 and SPOT 4) was acquired from two of three vendors, with image acquisition from Ikonos delayed until green-up in 2001.

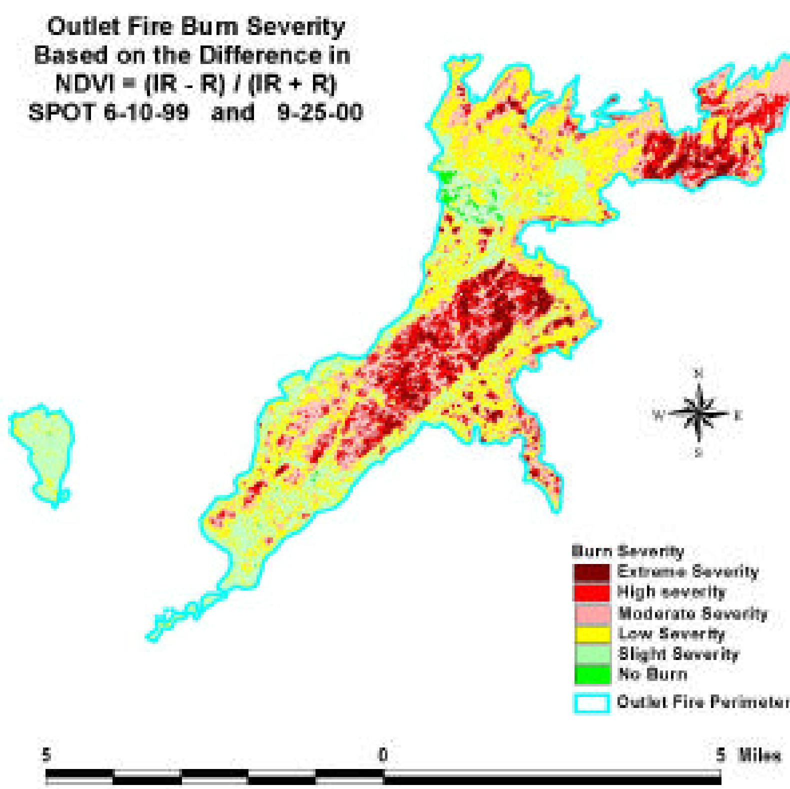

Figure 9.3. NDVI of SPOT 4, Outlet Fire, 2000.

SPOT. Differencing SPOT scene pairs required more noise filtering (changes detected independent of the change due to fire). SPOT scene pair differencing produced a lower change value amplitude, perhaps due to the increased selectivity (narrower spectral band widths) of its sensors.

For both before and after imagery, normalization of the differences between SPOT 4 bands 4 and 3 was successful, and change detection performed on these before and after NDVI images provided the most sensitive (widest amplitude) SPOT 4 burn severity estimation. Normalization of the differences in burn ratio requires spectral band ranges not found with SPOT 4 sensors, and so the technique was not performed with SPOT 4 image pairs.

Landsat. Performing a change detection operation on the band combination of 4, 5, and 7 between imagery pairs yielded the widest amplitude of any other band combination, from either Landsat or SPOT imagery pairs. Performing an unsupervised classification of the above operation resulted in a similar amplitude and spatial representation. Recognition by the unsupervised classification of these similar values and shapes supports the hypothesis that the change being measured is the change caused by the Outlet Fire. Performing a change detection operation on image pairs that had their *vegetation index differences normalized* provided a more discriminating, sensitive classification of burn severity. Of all operations undertaken from either satellite platform, performing a change detection operation on image pairs that had their *burn ratios normalized* provided the most discriminating and sensitive classification of burn severity.

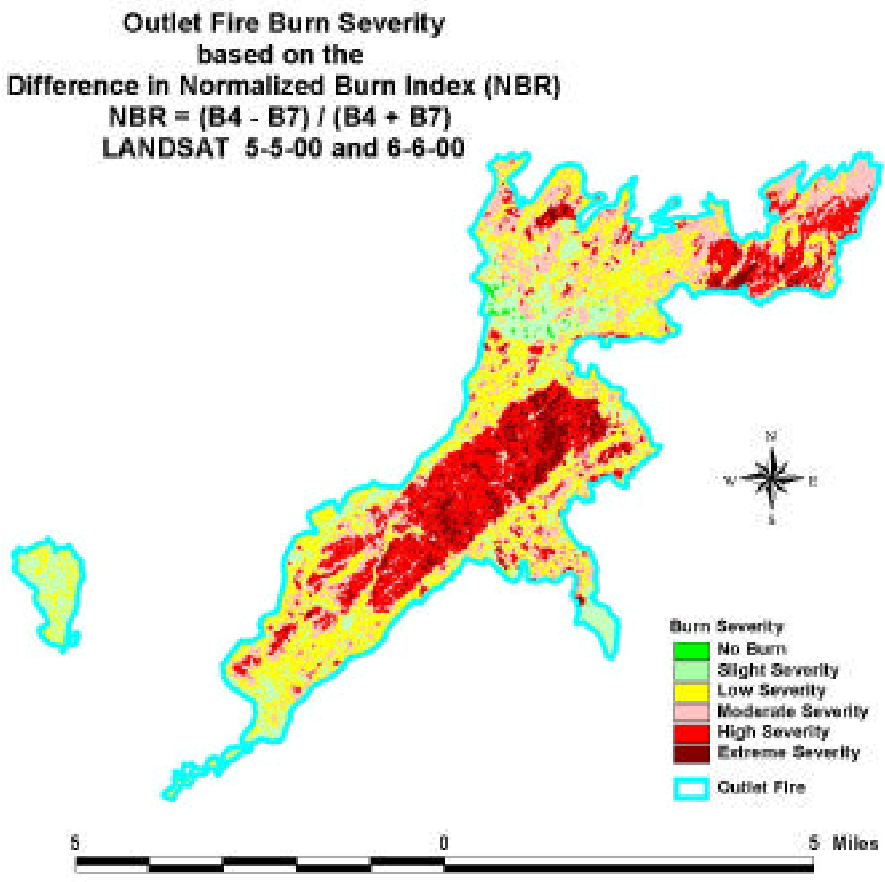

Figure 9.4. "Differenced" NBR of Landsat 7 before and after images.

Conclusion

Increasingly, rapid mapping of burn severity is becoming an integral part of the wildfire suppression process. Primary usage is in burned area emergency rehabilitation; specifically, to prioritize rehabilitation efforts that follow immediately after large fire control. Mapping from the ground (or from low-elevation airborne platforms) can be the most accurate assessment of fire severity for smaller fires. As fire area and burn severity increases, the time- and cost-effectiveness of ground assessment diminishes quickly. Techniques such as change detection, image classification, NDVI, and NBR provide increasing accurate and precise assessments of fire severity. Increased image availability, reasonable image pricing, and the average national park GIS department's capability to process, enhance, and analyze satellite imagery all provide impetus for recommending remote sensing technologies for the task of fire severity mapping. For national parks with a need for resource monitoring, the purchase of annual satellite imagery could go hand-in-hand with these fire management applications. Efforts in Grand Canyon National Park are underway to incorporate satellite imagery analysis in support of the fire effects monitoring portion of the prescribed fire management program.

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10 Remote sensing technique for microtopography in endangered species habitat

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History and setting

There is perhaps no more obvious an example of boundary conflicts of human and natural systems in the whole world than the Florida Everglades. Over the last 100 years, the human population of South Florida has exploded from mere thousands to 5 million. The conflicts in values expressed in alterations to the landscape reflect how the human values have changed.

Dividing to conquer

The Everglades are all about the need to control water. The first concerted effort, which took place in 1906, drained Lake Okeechobee to provide water for vast sugar cane and produce farms. Devastating hurricanes in the 1920s caused widespread flooding, the loss of over 1,200 lives, and a public outcry for flood protection. The U.S. Army Corps of Engineers dammed the lake's southern end, and a wider web of drainage canals spread across the wetlands to drain the excess water to the Atlantic Ocean. In 1947, environmentalists succeeded in creating Everglades National Park. In 1950, the state took management control of the water-control structures, such as gates, weirs, and levees, under the Central and Southern Florida (C&SF) Project. The creation of the Big Cypress National Preserve in 1974 added to the sheltered areas, but the booming crush of tourism-borne immigration in the 1970s and 1980s cemented the water conflicts between thriving populations and natural systems.

The physical and political fragmentation of the original Greater Everglades Ecosystem caused the compartmentalized form and function of current managed areas. More than half of the natural function of the original, natural Everglades—once comprising 10,800 sq mi—has been lost to agricultural conversion or urban development.

Dilution of powers

The federal government is the largest steward in South Florida, with about 2.3 million acres, but the South Florida Water Management District jurisdiction encompasses the entire hydrologic drainage basin. However, over 40 management agencies, special districts, departments, and organizations oversee over 75 distinct managed areas. A federal coordinating task force was organized through an interagency agreement in 1993. The 1996 Water Resources Development Act formally integrated 25 member organizations of tribal, state, and local governments into the comprehensive restoration scene.

As NPS Regional Director John J. Reynolds wrote, in a presentation co-authored with Christine Schonewald:

> Science will and must occupy a crucial center in the management of protected areas in the future. The scope of our paper does not focus on the biological or physical sciences.... Rather, it focuses on the interests of people and their values, and the need to bond protected areas to the societies within which they exist. It turns the early 20th century idea of 'boundary' inside out—no longer is a boundary

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a line of certain demarcation.... No, today a boundary must be seen as something like a 'diffusion filter.' But what a change! (Reynolds and Schonewald 1998).

The two key points of those statements are that we must focus on peoples' values, and that administrative boundaries are fuzzy illusions. Scientific laws, however, follow immutable rules that define the core issues.

Hanging in the balance

Extinction is an irrevocably crossed boundary. The Cape Sable seaside sparrow is a federally listed avian species that is *only* found in the freshwater prairies and marshes of the Florida Everglades. Loss of vegetative habitat and disruptions to its nesting and breeding cycles are the most prominent reasons for the decline of the species. The unifying cause is the water-management scenario—both cumulative and current (Lockwood and Fenn 2000; Mayer 1998). Besides flooding nests, unnatural alterations in the inundation duration have caused vegetation succession that has depleted the grassland habitat of the sparrow's preferred plant species, which is also linked with human management of the natural wildfire cycles (Bass and Kushlan 1982; Lockwood and Logan 2000). Most professional researchers agree that the species' demise may be perilously close (Pimm 1998).

Summarizing the situation, the U.S. Fish and Wildlife Service (USFWS) report *Balancing on the Brink (*USFWS 1998) stated that only three populations of the bird remain. The eastern (Ingraham Highway) population is at risk from fire and catastrophic weather events. The flood-endangered northeastern population, now at 50% of its former size, is not recovering. The Big Cypress population, at only 10% of its former size, is nearly lost (Curnutt et al. 1998).

These almost-sedentary birds move only about 160 m in the nests' home range (Morrison and Dean 2000). Their survivability is intrinsically linked with the hydrology and deep soils for nest-protection vegetation density (Orians et al. 1996).

The management phrase "adaptive planning and management" acknowledges the fact that policy and practice are tenuous experiments, to be modified as additional knowledge accumulates. Adaptive management is composed of three elements: models, support studies, and monitoring. *Models* frame the concepts, *support studies* lead to management alternative options, and, after an alternative is chosen, information from *monitoring* the effects of implementation will refine the conceptual models or alternative options. There are very significant gaps in the basic information and project design. These "certainty factors" have yet to be resolved: resolutions in time and space; process assumptions; the amount, frequency, and quality of data; calibration of the models; and acceptable ranges of error (Goodwin 2001)**.**

"Bathtubs and barriers"

Models used in management of the Everglades hydraulics, hydrology, and animals include the following.

- The eminent South Florida Water Management Model (SFWMM, or WMM) is the source of other models' topographical inputs. Used for water allocations since the late 1970s, it is a regional simulation of the hydrologic cycle: rainfall, evapotranspiration, infiltration, surface and groundwater flow, canal hydraulics, and withdrawals. Its analysis cell-size of 2x2 mi simulates *regional* effects very well.
- The Natural Systems Model (NSM) simulates the hydrologic response to the pre-drainage (pre-modern human) landscape based on estimated original vegetation. Elevation inputs are from SFWMM. NSM relies strongly on rainfall inputs and evapotranspiration.
- The SIMSPAR carrying capacity model uses cells of 500x500 m to represent areas of similar vegetation, topography, and hydrology, as well as

breeding territory density habitat type for Cape Sable seaside sparrow populations. The life history and behavioral characteristics are based on field observations of the species over a 15-year period, and were validated using historical records of daily water levels (Comiskey et al, undated). Although it uses 5- to 16-cm water heights to favor nesting, it does not allow for fire vegetation-succession effects. The model predicts the impact of proposed alternative hydrologic scenarios (Nott 1998). The processes of mortality, mate choice, and dispersal are expressed as simulations.

- The Across Trophic Levels System Simulation model (ATLSS) model uses a higher-resolution form of a "pseudotopography" that is derived from the combination of current vegetation classifications and hydroperiod classifications (USGS-BRD and IEM 1998). It models the ponding-duration and water-level stage. It uses the SFWMM, 2-mi-square cells, but, because of post-processing, calculates within an area of 28.5 sq m.
- The Everglades Landscape Model (ELM) recognizes the bounding effects of levees and canals within six individual sub-basins. That is, the amount of water going *in* must equal that going *out*, less evaporative losses to the atmosphere or transpiration by vegetation. This model is the theater for the combined operational and structural tests. It is a responsive model, using field-monitoring sites and "trigger" events.

All of the models are useful at a regional scale. All models make assumptions in the absence of crucial data.

As the water levels change, there are extremely subtle topographical contour changes in sparrow habitat that form moving boundaries (also known as "drying fronts"). *Regional-scale models should not be used to form predictions on events dependent on a much finer scale of responses.*

Using micro-topographic laser-mapping techniques, the hydrologic limitations delineated by the moving inundation front could be accurately tracked in the field. Knowing the timing and duration of the flooding and "dry-downs" of the grass prairies is also necessary because of attempts to recover original conditions.

Solutions for understanding

More accurate topographic data will produce more realistic model results (DeAngelis et al. 1998). The scientists, modelers, and agricultural interests realized this need and convened the U.S. Geological Survey (USGS) Topography Interest Group. Two methods were tested.

The airborne laser terrain mapper (ALTM) sensor collects backscatter readings (incidental reflections after the light beams hit something) from up to 10,000 LASER pulses emitted per second. The source is swinging from side-to-side along a flight path. The resultant time differential indicates the relative elevation. This system produces enormous amounts of data over a 1,200-m wide swath. A digital terrain model (DTM) with vertical accuracy of up to +/-3 cm can be generated, but 10 cm is what is consistently possible. The ALTM project was a cooperative effort with the USGS Biological Resources Division, the National Park Service, the University of Florida, and Optech, Inc. Simultaneous orthophotography capture is available.

The USGS's airborne height finder (AHF) uses a helicopter-mounted global positioning system unit to precisely locate its position, then a servo-mounted probe is lowered until the servo's clutch senses a set change in the cable-lowering resistance. The cable length is read and topographic height calculated. The results are surprisingly accurate (Desmond et al. 2000). By using the tops of surveyed benchmarks, the AHF was calibrated to have approximately a 3-cm relative vertical error. This program is sampling the southern Everglades on 400-m grids that will produce a regularly sampled digital elevation model (DEM).

Action solutions

The Army Corps of Engineers and USFWS agreed to develop reasonable and prudent alternatives (RPAs) that are consistent with the USFWS Final Biological Opinion (the "Jeopardy Opinion") on the sparrows). These RPA model parameters would be tied to the Interim Structural and Operational Plan model for year 2000. The RPAs are explicit operating rules for water delivery, as measured at key field sites. As an example, a rule might read: "To ensure that the water levels at NP-205 stay below 6.0 feet for a minimum of 60 consecutive days starting March 1." There have been agreements and test programs for water releases into Everglades National Park over the years, such as the Experimental Water Release Project that was started in the 1980s (NPS 1993). The Modified Water Deliveries Project, which relied strongly on the ELM of edge-bound sub-basins, was also a monitored-release design. That project proceeded in steps, with differing alternatives (USACE, 1992; Van Lent, Snow, and James 1999). Allowances for rain-driven operations, triggering events which alter the structure-management schedules, and rules for importing or pumping between other sub-basins are today's management reality.

Lessons for management

The important, prevalently held realization is that communication is the most productive manner to resolve conflicts. Long-term collaboration is the preferred mode of negotiation, because consensus is required and the concerns are too important to be compromised. Compromise—better suited to temporary settlements while under unavoidable time pressures—does not fit these conditions.

Input from the biological community has been effective (Pimm 2000). Hydroperiod performance measures are now accountable. It is to be hoped that the effects of modified prescribed fire management and water releases, combined with monitoring the nesting and breeding success, will increase the available habitat and allow the Cape Sable seaside sparrow population to survive and revive.

The scientific community has established communications forums that involve the management and leadership councils. The formal, interagency restoration partnership provides a comprehensive management framework for the professional teams to discuss issues and strategies. The more people talk, the more we find out that no person puts *any* value on an extinction.

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11 Spatial decision support systems for assessing impacts of landscape change in greater ecosystems

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Introduction

Economists consider natural landscapes in the Pacific Northwest to be more economically important in protecting water and air quality, recreational opportunities, scenic beauty, and fish and wildlife habitat than in supplying timber, food, fish, and minerals. A healthy environment is essential for a healthy economy, and the quality of the natural environment in the Pacific Northwest has tremendous economic value and is one of the driving forces behind increased employment, income, and industrial diversification (Pacific Northwest Economists 1995). Unsustainable use of natural landscapes is especially detrimental to the economies of greater ecosystems because of their heavy dependence on scenic attractions and outdoor recreation.

A major challenge facing land managers and planners in greater ecosystems is to distinguish between the impacts of natural and human-caused disturbances. Natural forces, such as fire, windstorms, avalanches, landslides, tree fall, floods, insect epidemics, and climate variability, strongly influence and shape ecological processes. Human activities have three major types of global impacts on the biological productivity and ecological integrity of landscapes: raising concentrations of carbon dioxide in the atmosphere due to the burning of fossil fuels, increasing fixation of nitrogen through the production of industrial fertilizer, and changing land use and land cover (Hansson and Wachernagel 1999). There is general agreement that human-induced land-use/cover changes have the most significant impact on ecosystems (IIASA 1998; Mac et al. 1998; Vitousek 1994). Some of the most adverse impacts of land-use changes stem from urbanization, conversion of lands to agriculture, drainage of wetlands, and fragmentation of forests (Mac et al. 1998). Specifically, changes in land use have a strong and dominant influence on spatial and temporal changes in the structure and functioning of ecosystems (Vitousek et al. 1997).

This paper discusses how geospatial analytical techniques (remote sensing, GIS, and GPS) can be used to develop a spatial decision support system (SDSS) that allows protected area managers, resource management agencies, regional planners, and stakeholders to predict regional changes in land-use/cover and landscape structure, and their impacts on ecological integrity and economic activity. The SDSS integrates three elements: a) an ecosystem-wide regional assessment of land-use/cover changes, b) a functional model that predicts regional landscape changes in response to biophysical and economic drivers, and c) regional impacts of predicted landscape changes on ecological integrity and economic activity.

Regional land-use/cover changes

Regional assessment of landscape changes is evaluated in three steps. In the first, past and current land cover maps are generated for the entire ecosystem using Landsat TM triplicates for the 1980s, 1990s and 2001. In the second step, a land management zone map is created by combining GIS layers for hypsography, geographic features, administrative boundaries, existing road networks and land ownership, a land cover map created using the triplicate scenes, and management objectives for

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different land areas. Land management zones are the geographic units for predicting landscape changes. Three primary management objectives are used to delineate land management zones, namely, protection, resource management, and development. Protected zones include national parks, wilderness areas, and wildlife refuges. Resource management zones include special-use, general recreation, and multiple-use areas. National forests are an example of a multiple-use area. Development zones are devoted to residential, commercial, and industrial uses.

In the third step, landscape change patterns over time are quantified based on landscape structure attributes, such as fragmentation, aerial extent, patchiness, patch density, interspersion, juxtaposition, and others for each land management zone using FRAGSTATS software (McGarigal and Marks 1995). Finally, landscape changes between years are used to estimate transition probabilities for conversion of land from one land-use/cover class to another in each land management zone (Baker 1989; Hall et al. 1988; Luque et al. 2000).

Functional landscape model

The functional landscape model explains how economic development affects land use and economic activity and how land-use changes affect landscape structure and ecological integrity. The functional landscape model consists of an economic projection sub-model and a landscape change prediction sub-model.

Economic projection sub-model. The economic projection sub-model determines how changes in final demand alter gross output, income, employment, and population. Final demand is the sum of personal consumption expenditure, investment expenditure, government expenditure, and net exports (exports minus imports). Increases in final demands are serviced in two ways. First, goods and services flow into the local economy from other regions. The flow of money generated in this manner constitutes the export sector. Second, increases in final demands are serviced by production of goods and services within the geographic boundaries of the local economy for local consumers, such as individuals, households, businesses, and government. The flow of money generated by local economic activities denotes the secondary sector (Summers and Field 2000). Growth in export and secondary sectors increases residential and commercial development, production of food and fiber, government facilities and services, transportation networks, and community infrastructure, which in turn increases the demand for land. Growth in final demand causes changes in land-use/cover and conversions of land from one use or cover type to another. Gross economic output, personal income, and total employment for each county in a greater ecosystem are determined using the Impact Modeling for Planning (IMPLAN) models for the counties that constitute the ecosystem (Lindall and Olson 1993).

Total land required to support projected or scenario-based increases in final demand are determined for the years 2010, 2020, and 2030 in each of the counties that constitute the greater ecosystem. Specifically, estimated final demand is multiplied by the amount of land required per $1,000 of final demand to obtain projected land-use requirements for each sector in a county. Land-use requirements per $1,000 of final demand for a sector are estimated by dividing the amount of land used by that sector determined from the 2001 TM image and 2000 census data by the gross economic output of that sector estimated from the IMPLAN model. Land-use requirements by sector and county are used in the landscape change prediction sub-model.

Landscape change prediction sub-model. The landscape change prediction sub-model involves two processes. In the first, the following spatially dependent transition probabilities are used to determine the most likely land-use changes within each land management zone in the ecosystem:

$$f_{xyt+1} = P_{xyt} f_{xyt}$$

where f_{xyt+1} and f_{xyt} are vectors of fractions of location x,y in particular land-use/cover classes at time t+1 and t, respectively, and P_{xyt} is a local transition probability matrix for conversion between land-use/cover classes in location x,y at time t. The most likely land-use changes within land management zones in a county are determined by combining the average transition probabilities for a land management zone with the county land-use requirements determined using the economic projection sub-model.

In the second process, converted lands are spatially allocated within each land management zone using a best-process technique or prescriptive technique. The best-process technique uses the local transition probabilities to identify areas with the highest probability of conversion. For example, if 20 acres of a zone are converted to a particular land use, then cells with the highest local transition probabilities for conversion to that use are selected until the 20-acre requirement is achieved. The prescriptive technique determines the spatial pattern of land changes in a land management zone using a multiple-criteria utility function (Prato 1999). The spatial allocation giving the highest utility score is selected.

Ecological impacts of predicted landscape changes

Regional ecological impacts of predicted changes in land-use/cover are evaluated using two types of landscape structure metrics: a) the frequency of object (patch) characteristics, such as the number of patches in a specific size class and diversity of patch types, and b) the spatial relationship between different objects, such as inter-patch distance (Griffiths et al. 1993). These metrics influence species diversity and abundance and other measures of ecological integrity and biological diversity. Landscape structure metrics include: patch number size, shape, and perimeter, patch size coefficient of variation, isolation, connectivity, relative richness, relative evenness, relative patchiness, matrix porosity, diversity, dominance, fractal dimension, nearest neighbor probability, contagion, edges, and vegetative cover (Forman and Godron 1986; Turner 1989).

Economic impact assessment

County-level economic impacts are determined by substituting the projected or scenario-based increases in final demands for 2010, 2020, and 2030 into the IMPLAN models for the counties that constitute the ecosystem. Economic impacts are measured in terms of county-level gross output, personal income, and employment. Regional-scale economic impacts are determined by summing county-level impacts.

Integration with SDSS

An SDSS offers new insights into the structure of spatial decision problems by helping users generate new alternatives and strategies in a problem-solving process (Wherrett 1996). The TM images, historical changes in land-use/cover based on those images, the landscape change prediction sub-model, the economic projection sub-model, landscape structure metrics, and supporting databases are integrated into an Internet-based SDSS. Design and development of the SDSS utilizes client server transactions wherein the client (user) makes a request to the server and the server gives the results back to the client (Harder 1998). This task is accomplished using various software, including ArcView GIS and Internet Map Server (ArcView IMS or ArcIMS), the ArcView Image Analysis (AIA) extension, Java, JavaScript, HTML, and Avenue programming.

The SDSS allows protected area managers, land-use planners/managers, stakeholders, and policy-makers to: a) evaluate the ecological and economic impacts of predicted landscape changes, b) determine tradeoffs between economic and environmental impacts, and c) evaluate the effectiveness of alternative land-use policies and conservation strategies in alleviating undesirable ecological impacts of predicted landscape changes. In particular, the SDSS allows users to evaluate policies and strategies such as land donations, land exchanges, conservation easements, land-use restrictions, and others (Brown 1999). The SDSS can be used to compare the ecological and economic impacts of alternative policies and strategies.

Conclusions

Human-induced changes in land use and land cover often have significant ecological and economic impacts that are especially acute in ecologically sensitive greater ecosystems experiencing rapid economic development. Rapid advancements in geospatial analytical techniques (remote sensing, GIS, and GPS) make it possible to develop SDSSs that allow protected area managers, resource management agencies, regional planners, and stakeholders to predict regional changes in land-use/cover and landscape structure, and their impacts on ecological integrity and economic activity. An SDSS is proposed that integrates an ecosystem-wide assessment of land-use/cover changes, a functional model that predicts landscape changes in response to biophysical and economic drivers, and an assessment of predicted landscape changes on ecological integrity and economic activity. The SDSS incorporates TM images, historical changes in land-use/cover based on those images, a landscape change prediction sub-model, an economic projection sub-model, landscape structure metrics, and supporting databases. The SDSS allows protected area managers and others to evaluate the ecological and economic impacts of predicted landscape changes, determine tradeoffs between economic and environmental impacts, and evaluate the extent to which alternative land-use policies and conservation strategies alleviate undesirable impacts of future landscape changes in greater ecosystems.

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12 Preserving paleontological resources using photogrammetry and geographic information systems

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Introduction

The American West is a storehouse of fascinating paleontological resources that include the footprints and skeletal remains of dinosaurs. These important scientific and educational resources are often on lands managed by government agencies for the benefit of the nation's public. Land management agencies are challenged with providing public access to these resources, as well as preserving them for future generations. Conservation includes the scientific identification, documentation, curation, and monitoring of these national treasures.

The natural process of weathering, combined with the effects of public visitation—including those of vandalism, unfortunately—can significantly affect a site. Documentation, collection (when appropriate), and retention of data and associated materials in a suitable public repository, where the information can be preserved into perpetuity, are vital. An excellent documentation tool is three-dimensional (3-D) data capture. Photogrammetry, conventional or global positioning systems (GPS) surveying methods, and ground-based laser imaging are techniques that can provide highly accurate 3-D representations of fossil resources.

Vertebrate ichnology at the Red Gulch Dinosaur Tracksite

The Red Gulch Dinosaur Tracksite (RGDT) is a newly reported (Breithaupt et al. in press) paleontological resource. Located near Shell, Wyoming, the RGDT is a 1,600-sq-m area of land administered by the Bureau of Land Management (BLM) in the eastern Bighorn Basin of northern Wyoming. This site is unique in North America and represents a significant paleontological resource that is being developed for the educational benefit of the public. In a cooperative partnership with the BLM, investigators have supported development of the site as a unique tool for public education. To that end, the investigators have assisted in the creation of interpretive displays and Web sites, as well as disseminating accurate information to the media.

Over the past three years, dinosaur tracks were located, mapped, measured, described, surveyed, photographed, and compared with other previously studied track assemblages. Analysis of this data is providing unique insights into the community structure and habitat of Middle Jurassic dinosaurs in northern Wyoming. Because of the density of tracks, degree of surface exposure, proximity to the road, and BLM development plans, the primary focus of research at the RGDT was an arroyo ("dry wash") exposing a limestone unit of the lower Sundance Formation. This unit historically has been defined as open water marine in character (Darton 1899). However, this discovery demonstrates an episode of subaerial exposure during regressive phases of the Sundance Sea. Geologic work in the area has assigned the track-bearing unit to the Middle Jurassic Bathonian-age (165 million years old) Canyon Springs Member of the Sundance Formation (Schmude 2000). Any evidence of dinosaur activity from the Middle Jurassic is significant, as this was a period worldwide which

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preserves little terrestrial deposition, and a very limited vertebrate fossil record (Shubin and Sues 1991).

The dinosaur tracks at the RGDT are preserved as impressions in a gray, ripple-bedded, oolitic, peritidal limestone. All of the tracks are tridactyl pes impressions ranging in length from 8 to 30 cm (Figure 12.1). The majority of tracks have three distinct digits, a very faint "heel" imprint, sharp claws, and foot lengths greater than widths. This track morphology is consistent with those generally attributed to theropod (meat-eating) dinosaurs (Thulborn 1990). The tracks were all created by small- to medium-sized theropods ranging in weight from tens to hundreds of kilograms.

Figure 12.1. Beth Southwell measuring a dinosaur track at the RGDT. Close-up of a dinosaur track (inset upper right).

Over 1,000 theropod tracks have been discovered at the RGDT, making it the most extensive dinosaur tracksite known in Wyoming. Arranged into at least 125 discrete trackways (ranging from 2 to 45 steps), these tracks offer a unique glimpse of dinosaurs walking close to the shore of an inland seaway. Mapping efforts (Breithaupt et al. in press) documented over 630 tracks (representing 40 trackways) in the southern part of the arroyo (known as the "Ballroom") and approximately 280 tracks (representing 49 trackways) in the northern part of the arroyo ("Discovery Area"). The majority of the trackways show preferred orientations with trends of parallel to subparallel groupings to the south and southwest, suggesting gregarious behavior. However, several solitary trackways trend in opposite directions. Analyses of these various trackways with regard to time sequencing, origin, direction of travel, speed, and changes in morphology are currently in progress. Because of the large number of tracks and their extent, important morphological and preservational variations within and between trackways can be analyzed. Irregularities in track morphology, step length, straddle width, and trackway paths relate to variations in substrate microenvironments or to intracommunity dynamics (Breithaupt et al. in press).

Standard vertebrate ichnological field methods discussed by Thulborn (1990) and Lockley (1991) were incorporated during the study of the RGDT. The tracks were located and sketched onto a map with a scale of 1 in = 1 m. The 1-m grids for this map of the track-bearing horizon were laid out on the outcrop surface utilizing a Topcon standard two-person total station and a Geodimeter System 4000 one-person total station with remote positioning unit. Detailed descriptions and measurements were taken on each track. This information included identification number, size, shape, and arrangements of digits, with special attention being paid to the presence of distinctive track features. Over 20,000 track attributes were recorded at the RGDT and entered into an Excel spreadsheet. In addition, the location of toe and heel points for the tracks in the Ballroom were captured using the Geodimeter System 4000 total station. An ArcView point theme was then generated from the surveyed coordinate data and linked to the data in the Excel spreadsheet and integrated with other geographic information systems (GIS) elements (Naus, Matthews, and Southwell 1999).

Photogrammetry at the RGDT

In addition to traditional vertebrate ichnology documentation techniques, photogrammetry (i.e., making measurements from photographs or other remotely sensed images) was utilized at the RGDT. To preserve the data from this unique paleontological site, monitor weathering, and facilitate the scientific research, the RGDT was intensively photodocumented. Imagery of the tracksite ranged from 30-m-resolution satellite data to close-range (object-to-camera distance of less than 300 m) photogrammetric images of a single track. Large format (9x9-in) natural-color aerial photography (scales of 1:3000 and 1:1800) was used to produce digital terrain models, digital orthophotos, and topographic contour maps of the entire 1,600-sq-m area.

Large-format aerial photography, while suitable for developing management and recreation plans for the RGDT, did not provide the level of detail needed to illustrate track and trackway relationships. To fill the gap, a 35-mm camera was mounted on a low-altitude remote-controlled airplane and used to photograph the dry wash. The resulting photographs were scanned, mosaicked, and registered to the digital orthophoto (Figure 12.2). In addition, the Ballroom was photographed from an ultralight aircraft. However, camera motion was a noticeable problem for pictures taken from the planes. To rectify this problem, a tethered blimp with a 50x70-mm-format camera and lightweight video camera was used at the RGDT. This system consisted of a 6-m-long, helium-filled blimp, which was capable of lifting a camera to 76 m above the ground. The on-board camera is electronically positioned from the ground and can be oriented to acquire photographs that are nearly vertical to the subject (Figure 12.3).

To further preserve and record the paleontological resources on the main track-bearing surface, close-range photographs (174 cm above the surface) were taken of each 1-m grid in the arroyo that contained a track (Figure 12.4). A Rollieflex 3003 metric 35-mm single-lens reflex surveying camera was utilized. These photographs were scanned, and rectified to the 1-m mapping grid.

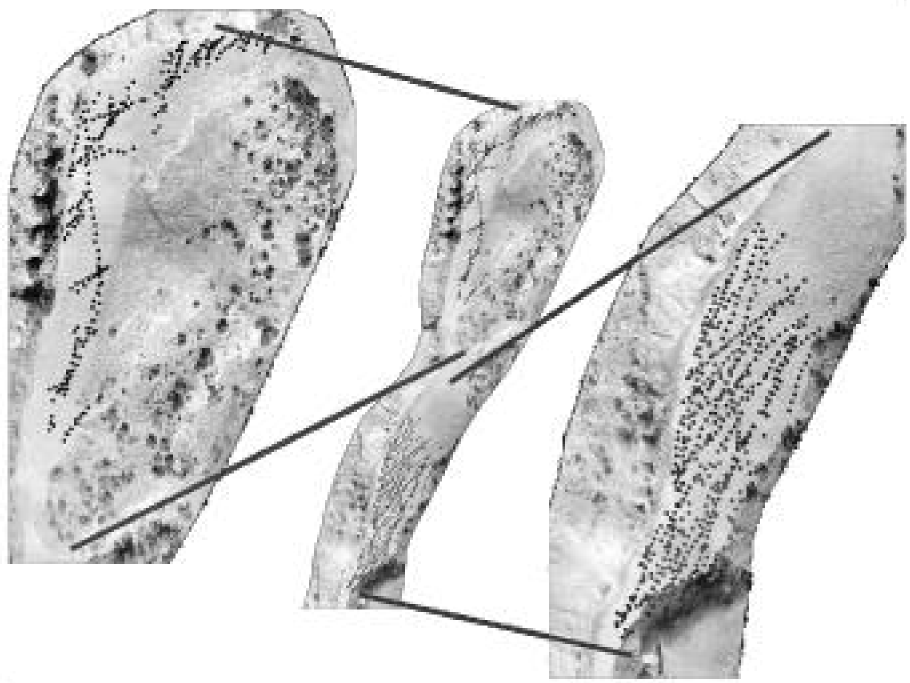

Figure 12.2. RGDT dry wash (photo from low-altitude remote-controlled airplane) with track points located from total station. Left image: Discovery Area (north); center image: entire dry wash; right image: Ballroom (south).

Stereoscopic photogrammetry at the RGDT

Stereoscopic photogrammetry was used as a noninvasive strategy for collecting three-dimensional data about selected tracks (Matthews and Breithaupt in press). In order to provide horizontal and vertical control at the needed level of precision, and a 1.05-sq-m grid was used. Stereoscopic photographs were taken with the Rollieflex surveying camera. This camera has a matrix of fiducials that are imprinted on each frame and a calibrated lens. Three photographic stations were occupied for each subject set-up. These photographs were set up in on an analytical stereoplotter where an interior, relative, and absolute orientation were then performed. This procedure combines the camera calibration information, the location of the photographs in the instrument, with the ground-control coordinates. The result is a geometric reconstruction of the field subject in an analytical environment (Friedman 1980). In this environment, detailed x, y, and z information can be extracted. Surface data was collected at evenly spaced 10-mm intervals, producing a Digital Terrain Model (DTM). The DTM data were brought into ArcView, where a contour map with a 2-

mm interval was produced. DTM data were also imported into EarthVision Geologic modeling software and a surface was generated. This surface was rotated in 3-D space and viewed from various perspectives (Figure 12.5). An image of the tracks was digitally draped over the surface, providing a virtual digital reproduction of a portion of the track surface. These images allow paleontologists to do detailed measurements and analyses in the lab. Valuable statistical comparisons of within-trackway and across-trackway variability in footprint shapes can be observed and calculated. Not only can important information be obtained about the track maker from detailed 3-D data, but also a clearer understanding of the preservational history of the tracks and the depositional environment can be attained.

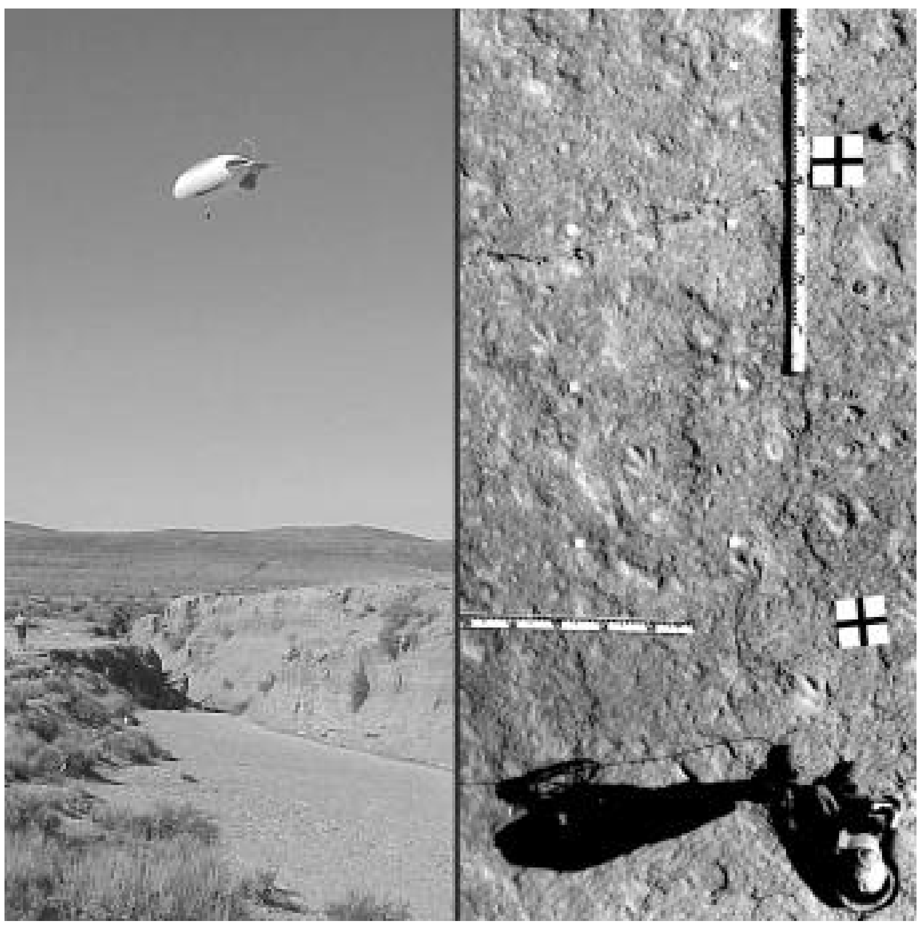

Figure 12.3. Tethered blimp with mounted camera over the Ballroom (left). Low-level aerial photos from the blimp of tracks in the Ballroom (right).

Documentation of a dinosaur bonebed

For the past two years, photodocumentation of a Late Jurassic Morrison Formation dinosaur bonebed (Virginia Museum of Natural History Locality 186) in the eastern Bighorn Basin of northern Wyoming has been conducted. To capture the spatial relationships of the fossilized skeletal material, close-range photogrammetry has been used. The camera blimp system was also used at this site to document the ***in situ*** contextual relationships of articulated and disarticulated remains of *Apatosaurus*, *Stegosaurus*, *Camptosaurus*, *Allosaurus*, *Diplodocus*, and *Camarasaurus*. Photographs of the quarry provide a visual and spatial record of the location and relationships of the skeletal material extracted during each field season. A mosaic of photographs from successive years can reveal associations which could only have been recognized if the entire bonebed was exposed at one time. These spatial relationships can be quantified and their 3-D relationships examined in greater detail, both spatially and temporally utilizing GIS.

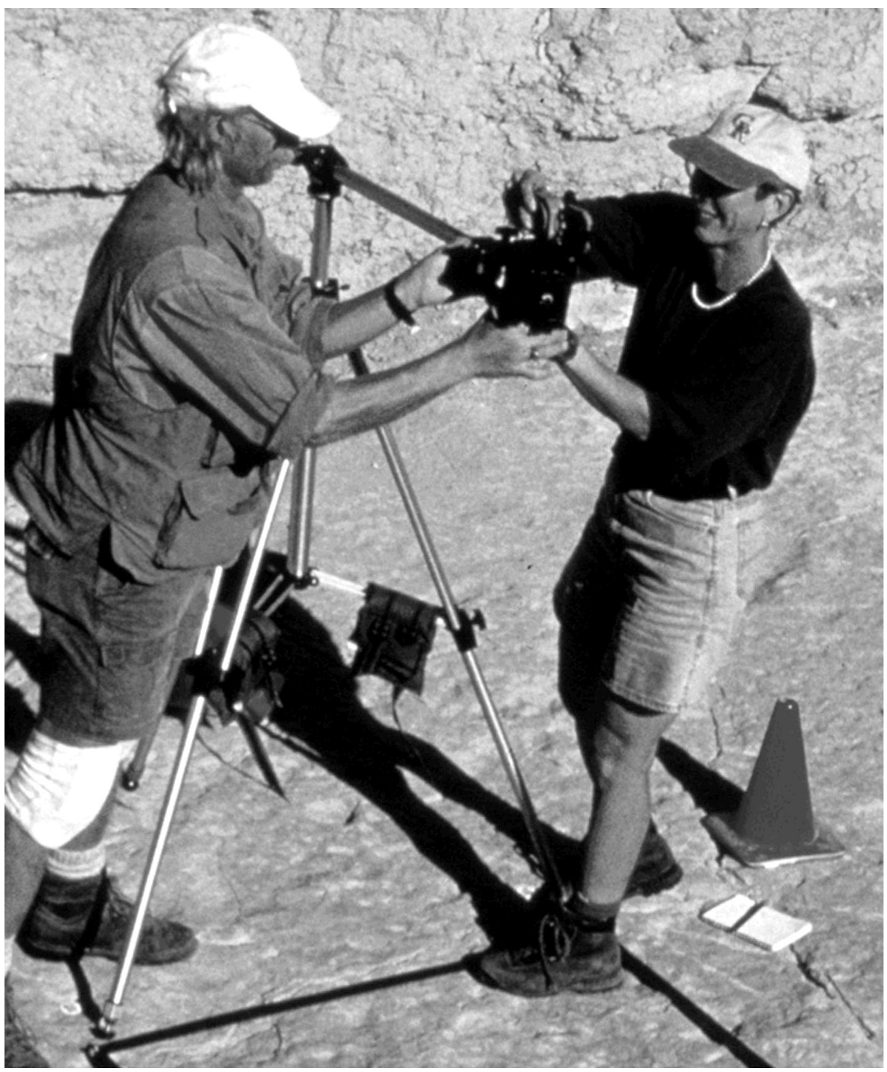

Figure 12.4. The authors conduct photogrammetric documentation of a 1-m grid in the Ballroom.

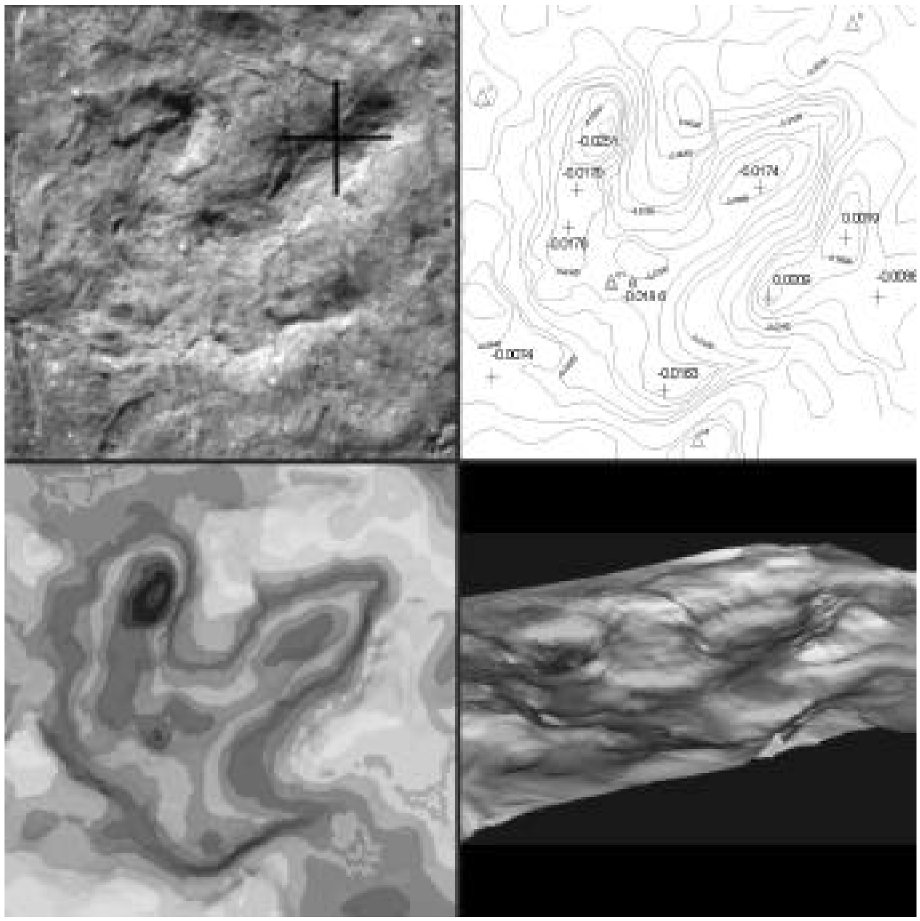

Figure 12.5. Photo of a RGDT footprint (upper Left); digital contour of track (upper right); DTM of track, planar view (lower left); and DTM of track, oblique view (lower right).

Three-dimensional laser data collection

State-of-the-art advances in the field of laser technology have changed the face of 3-D data collection. High-speed, high-accuracy laser radar scanning systems have made it possible to collect 800 x, y, and z data points per second. These data points have a positional accuracy of +/- 6 mm when scanning at distances of less than 50 m. This system returns a very precise and dense cloud of 3-D data. The laser system is a transportable, robust field unit that provides near-real-time access to the data. An advantage of this system is that measurements can be made directly from the point cloud data in the field. These data can be utilized in a variety of software packages for the production of 3-D surfaces, contours, and site visualization.

The value of laser technology to paleontology has only begun to be explored. Because of the portability of the equipment, a variety of sites and specimens have been investigated. Variations in surface textures between bone and matrix can result in a difference in the intensity of the laser return. This property can be utilized to distinguish the bone from matrix within the point cloud data. Manipulation of the data within a digital environment allows for virtual reconstruction of quarry sites and skeletons. In addition, dinosaur footprints can be documented in this manner. Laser scans can be incorporated with other documentation methodologies, resulting in highly accurate data capture. The point cloud data can be utilized to generate a digital surface upon which images can be draped. Three-dimensional laser imaging technology shows great promise for the documentation, study, interpretation, and archiving of paleontological resources.

Conclusion

Close-range photogrammetry, as well as other scientific observations, has been integrated into a real-world, rectangular coordinate system that provides the framework for a GIS of the RGDT. The GIS is used to analyze the relationships of the scientific data in 3-D space, and to build 3-D models of select tracks found at the site. Detailed measurements, such as DTMs and topographic contours, can be produced for the individual tracks. These models preserve information about the footprints that may be lost through time as the result of illegal collection, vandalism, erosion, and human interaction, and can be used to monitor and manage the RGDT in the future. The 3-D data collected, whether from photogrammetric analysis or laser scanning techniques conducted systematically over a number of years, will provide insights into the effects of weathering, including a quantifiable volume of surface material removed (Inkpen 2000). As the data are in a digital format, they can be viewed at a variety of scales and rotated, allowing observation at any angle. In addition, the digital data file and the image-draped surface can be distributed over the Internet, where the virtual fossil tracks or bones can be made available to researchers around the world, as well as the public, to study and enjoy. In addition, 3-D data can be used for automated casting to produce solid models (Chapman 1997).

Incorporating GIS documentation with traditional ichnology research methods in the course of the study at the RGDT has resulted in one of the most precise approaches ever for measuring, recording, and evaluating fossil tracks. In addition, various track documentation methodologies utilized at the RGDT are being compared as to their utility. State-of-the-art technology used at this site has resulted in the RGDT gradually becoming one of the most extensively documented dinosaur tracksites in the world.

Paleontological sites, although “withstanding the sands of time,” can be ephemeral due to erosion, vandalism, development, and casual human interest. In order to preserve the value of these important scientific and education resources, detailed 3-D data can be captured through the use of close-range photogrammetry. This imagery, combined with surveyed ground control, can be incorporated into a GIS for viewing and analysis. Close-range photogrammetry and GIS are being utilized at the RGDT and a Jurassic bonebed in northern Wyoming. In addition, 3-D laser imaging also shows exciting potential in the documentation, archiving, and research of paleontological resources.

Acknowledgments

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13 Effects of fenced transportation corridors on pronghorn antelope movement in Petrified Forest National Park, Arizona

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Introduction

Pronghorn *(Antilocapra americana)* is a species of special concern in Arizona and throughout other areas of the western USA. Intensified management is necessary to ensure that present population levels can be maintained. Because pronghorn have large home ranges and because land-ownership patterns in the West are quite diverse (i.e., there is "land checkerboarding"), proper management of this animal can occur only if management occurs uniformly across land-ownership boundaries.

Pronghorn are generally considered a nomadic mammal, moving among habitats in response to changing conditions due to drought, winter storms, forage and water availability (O'Gara and Yoakum 1992; Ockenfels et al. 1997). In some areas, it is believed that fenced rights-of-way fragment pronghorn habitat and restrict movements, thereby isolating populations or preventing migration to seasonal ranges (Buechner 1950; O'Gara and Yoakum 1992; van Riper and Ockenfels 1998). With the increased habitat fragmentation that is occurring throughout the West, pronghorn populations are having a more difficult time in maintaining traditional migratory behavior (Ockenfels et al. 1994; O'Gara and Yoakum 1992).

This study was initiated to examine how management of lands in northern Arizona, particularly National Park Service (NPS) areas, influenced home ranges and movement patterns of pronghorn. Our objectives were to: (1) document pronghorn movement patterns; (2) determine home-range sizes for adult female and male pronghorn; (3) identify what types of barriers isolated pronghorn; and, (4) ascertain how NPS management practices can influence movement among pronghorn populations.

Study area

We selected a study area that encompassed Petrified Forest National Park (Figure 13.1). Lands of this region are characterized by undulating terrain with rugged mesas or hills throughout, and numerous gullies extending from highly-eroded cliffs, similar in physiographic composition to much pronghorn antelope habitat throughout the western USA. Elevation within our study area ranged from 1,650 to 1,800 m, with the Puerco River being the only major waterway. Yearly precipitation is low (1941-1970: $\bar{x}$ = 18.7 cm), with over one-half of the rainfall occurring during brief thunderstorms during July–September (Sellers and Hill 1974). Average snowfall is only 12.4 cm.

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Figure 13.1. Relocations of radio-collared pronghorn within the environs of Petrified Forest National Park, Arizona (shaded area), during monitoring between 1992-1994 (Part A), and ongoing monitoring since December 2000 (Part B). In 1992-1994, pronghorn were captured and radio-collared both north and south of the BNSF railway line; in 2000, only pronghorn north of the railway were captured. Graphics courtesy of Arizona Game and Fish Department.

Great Basin grassland (Brown 1994) and juniper *(Juniperus* spp.) woodland dominate the landscape. Blue grama *(Bouteloua gracilis)* and alkali-sacaton *(Sporobulus airoides)* are the predominant grasses. Sagebrush *(Artemisia* spp.), saltbush *(Atriplex* spp.), rabbitbrush *(Chrysothamnus* spp.), and Mormon-tea *(Ephedra* spp.) are scattered throughout, often forming small thickets. Snake-weed *(Gutierrezia* spp.) is abundant in localized poorer-condition sites. Plant nomenclature follows Kearney and Peebles (1960).

Methods

Capture and location. Using a net-gun fired from a helicopter, we captured adult pronghorn in mid-October 1992 and then in January 2001. All animals were radio-equipped, ear-tagged, and released at their capture sites. We located pronghorn aerially and from the ground each month between October 1992 and September 1994, and then weekly from January to August 2001. The Universal Transverse Mercator (UTM) coordinates of detections were derived to the nearest 0.1 km from U.S. Geological Survey 7.5-minute maps, and we also used a (GPS) receiver to calculate coordinates. All UTM-coordinate files were transferred into an ArcView geographic information system (GIS). Statistical tests were performed with SPSS/PC+ software (Norusis 1990).

Movements. Using features in the software package HOME RANGE (Ackerman et al. 1990), we calculated movements for each animal. The 100% minimum-convex polygon method was selected as our estimate of home-range size, with a 50% convex polygon as the estimate of high-use areas. We tested for site- or gender-related differences, as well as site x gender interactions, in home-range and core use size with 2 x 2 ANOVAs. We used t-tests within each site for gender-related comparisons.

Results

Capture and relocation. We initially captured, radio-collared and ear-tagged 20 (15 females, 5 males) pronghorn in 1992. These animals were relocated 1,736 times (Figure 13.1). In 2000, we captured 9 antelope, 5 females and 4 males, and at present have 298 relocations.

General movements. Normality tests indicated that long-distance movements were not normally distributed, whereas mean distance and greatest distance between any two consecutive locations were likely sampled from normally distributed populations. Mean movements did differ ($F = 5.34$; df = 1,36; $P = 0.027$) by gender (Table 13.1); females ($x = 3.3$ km, SD = 0.5, $n = 28$) tended to move more in their home ranges than did males ($x = 2.9$ km, SD = 0.5, $n = 9$). No site x gender interactions were observed ($F = 0.72$; df = 1,36; $P = 0.404$), with much of the gender-related difference explained by a correlation ($r = 0.64$, $n = 37$, $P < 0.001$) between mean movements and greatest movements.

Specific movements. For the 20 adult pronghorn captured in the northeastern study site, females tended to move more ($t = 2.26$, df = 18, $P = 0.036$) than males, and greatest movements of females were more variable and exceeded ($t = 2.41$, df = 17.63, $P = 0.027$) those of males (Table 13.1). Most (76%) pronghorn exhibited at least some movements greater than 10 km. The 9 individuals captured in 2000 had similar movement patterns to those recorded in 1992-1994 (Figure 13.1).

Rights-of-way crossings. Crossings, by both females and males, of the paved but unfenced road in Petrified Forest National Park occurred throughout this study, with 165 crossings from 1992-1994 and 34 crossings recorded in 2001. However, we recorded no pronghorn crossing paved highways that were fenced (e.g., Interstate 40) or crossing the Atchison, Topeka, and Santa Fe (AT&SF) or Navajo spur railroad rights-of-way (Figure 13.1). In fact, some of the home ranges seemed bounded by these fenced transportation corridors. For example, pronghorn captured north of the AT&SF in 1992 and 2001 had home ranges bounded by the railroad right-of-way to the south and Interstate 40 to the north, resulting in a linear shape. Those captured south of the railroad in 1992 had non-linear home range shapes, more typical of pronghorn home-range patterns throughout the western USA (O'Gara and Yokum 1992).

Variable	*Females*	*Males*
n	15	5
Mean distance moved (a)	3.3	2.7
SD	0.6	0.4
Range	2.5-4.4	2.0-2.9
No. movements ≥ 10 km	36	7
No. movements ≥ 20 km	3	0
Mean of greatest distance moved (a)	14.4	9.0
SD	8.0	2.0
Range	6.0-35.0	6.5-10.6

(a) Distance (km) between 2 consecutive locations for each animal as calculated by HOME RANGE (Ackerman et al. 1990), then averaged for mean distance.
(b) Distance (km) between 2 consecutive locations.

Table 13.1. Movement characteristics of adult pronghorn antelope from 1992-1994 in the environs of Petrified Forest National Park, Arizona.

Home Ranges and Core Use Areas

Home-range sizes clustered in the 75-125 sq km range, with few encompassing <50 sq km, while 3 home ranges >250 sq km were for females that had made large-scale seasonal movements (Table 13.2). Home-range sizes did not vary by gender ($\underline{F}$ = 2.09; df = 1,36; $\underline{P}$ = 0.158), but home-range sizes and variability were larger ($\underline{t}$ = 2.15, df = 22.32, $\underline{P}$ = 0.042) for animals confined by the two fenced transportation corridors (i.e., freeway and railroad). There was no ($\underline{F}$ = 0.06; df = 1,36; $\underline{P}$ = 0.805) site $\underline{x}$ gender interaction. The greatest influence on home-range shapes of the radio-collared pronghorn was human-related development, particularly fenced highways and railroad rights-of-way.

Movement Enhancement Studies

Following the 2001 capture, animals were followed to make sure that they were not crossing rights-of-way. During the initial four months of 2001, animals maintained the same home-range structure that we observed from 1992 through 1994 (Figure 13.1). No animal crossed a fenced transportation corridor. All present fences along the railroad right-of-way have been georeferenced and entered into the park's GIS data base. In June 2001, at select locations we installed wildlife movement enhancement bars. We are monitoring pronghorn movements to ascertain if they utilize these structures. Following six months of tracking, if animals have not crossed the railroad right-of-way, fencing will be removed along the railroad tracks within the park boundaries. Monitoring of animals will continue over the next 12 months to ascertain when and where animals cross the railroad right-of-way.

Discussion

In our discussion we will first compare pronghorn home range and movements between our study site and other areas of the western USA. We will then discuss what did, or did not, constitute a movement barrier. A third topic of discussion will be the potential role national parks play in the management of pronghorn in northern Arizona and in other areas of the western USA. Finally, we will examine potential new management actions, framed in some of the management tools developed during this study.

Variable	***Females***	***Males***
n	15	5
Mean home-range size (sq km) (a)	124.0	81.7
SD	59.6	40.9
Range	56.5-243.2	44.4-140.0
Mean core use area (sq km) (a)	21.2	9.2
SD	5.4	7.4
Range	9.7-28.1	2.1-20.6

(a) Home-range size using 100% minimum convex polygon and core use area using 50% minimum convex polygon from HOME RANGE (Ackerman et al. 1990).

Table 13.2. Home-range characteristics of adult pronghorn antelope from 1992-1994 in the environs of Petrified Forest National Park, Arizona.

Movement and Home-range Comparisons

Movements. Differences in pronghorn movements that we found were partially related to the availability of a permanent water source. Within Petrified Forest National Park, the Puerco River provided permanent water throughout the year. However, north of the railroad pronghorn had to leave the park for livestock water sources.

Home-range comparisons. Pronghorn had significantly larger home ranges than recorded for other populations over the western USA. This was due in large part to the animals that were confined between the railroad and freeway rights-of-way. Ockenfels et al. (1994) also showed that in central and northern Arizona transportation corridors played a dominant role in pronghorn home range sizes.

Movement Barriers

Fenced highway right-of-way. Buechner (1950), working in Texas, recorded the negative effect that highway rights-of-way fences had on pronghorn movements. White (1969) demonstrated that fenced highways blocked the movement of pronghorn in northern Arizona during a severe winter storm, resulting in losses of as much as 80% of some herds. In central Arizona, Ockenfels et al. (1994) provided further evidence of substantial fragmentation of pronghorn habitat and isolation of pronghorn herds by fenced highways. From over 3,000 relocations during their study, not a single animal crossed a fenced highway.

Fenced railroad right-of-way. The AT&SF railroad line roughly follows the 35th parallel of northern Arizona, crossing through the middle of Petrified Forest National Park. In our study area, we demonstrated that pronghorn are isolated into discrete populations by the AT&SF railroad right-of-way. Similar fragmentation probably occurs in many other areas in the state and throughout the West, particularly if the railroad tracks are tightly fenced on both sides.

Unfenced rights-of-way. Although considerable traffic occurs seasonally on Petrified Forest park roads, these unfenced paved roads did not adversely affect the movement patterns of pronghorn during our study. Ockenfels et al. (1994) observed similar patterns relative to dirt roads (e.g., Dugas Road) in central Arizona.

Management Implications for NPS Areas

The extreme fragmentation to pronghorn populations in this study leads us to believe that rights-of-way fences are the major factor affecting pronghorn movements across their range in Arizona. This is accentuated in small management areas such as the many smaller national parks in Arizona. Fragmentation of habitat by fenced rights-of-way impairs movement of pronghorn and probably affects survival and genetics of those herds. To facilitate movement and interchange among herds, it is imperative that NPS make every effort to reduce the effect of fenced rights-of-way on pronghorn populations. The pronghorn can then freely move as perturbations occur (e.g., winter kills as described by White 1969).

Another factor affecting localized movement and influencing pronghorn home ranges in northern Arizona is permanently available water. Draw-down of the water table by wells, coupled with anthropogenic manipulation of the environment, have negatively influenced historically used watering sources. In fact, Bright and van Riper (1999) found that the greatest movement out of Wupatki National Monument to secure water took place during September, that time of year when pronghorn are hunted in northern Arizona.

Possible mitigation features that could be undertaken by NPS areas in northern Arizona include: (1) removing fences along rights-of-way; (2) expanding rights-of-way dimensions by placing fences further away from the road or railroad, then modifying those fences to permit better movement of pronghorn; (3) relocating rights-of-way out of pronghorn habitat; (4) relocating animals, particularly to the section of Petrified Forest north of Interstate 40; (5) providing permanent wildlife movement enhancement bars on fences along park boundaries; and, (6) providing signs on unfenced park roads warning visitors of wildlife movement corridors. Careful attention should also be given prior to any fencing of presently unfenced roads, highways, and railroads.

The issues confronting NPS areas in dealing with pronghorn management in northern Arizona are only an indication of a much larger problem facing managers of protected areas around the world. If managers wish to have their protected areas function as species reservoirs (i.e., sources instead of sinks), they have to: (1) begin to forge active partnership with contiguous landowners to manage resources on a much broader ecosystem basis (as was done with Petrified Forest National Park and Burlington Northern Santa Fe railroad); then (2) decide to what degree they are willing to allow hands-on active management to occur, particularly when managed lands cannot adequately support a species over its annual cycle; and, finally, (3) standardize (or partition) the degree of hands on management among *all* managers of areas within each ecosystem.

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14 Human impacts on golden eagles in northeastern Arizona

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In this paper I present information on general eagle biology, eagle populations in North America and the western USA, and specific information on eagles in and near Wupatki National Monument relative to the issue of Hopi collecting of eaglets for religious ceremonial use. I do not discuss ethnohistorical information or legal issues.

The golden eagle *(Aquila chrysaetos)* is very important in Hopi culture and religion. The Hopi have been collecting and utilizing eagles for hundreds of years at least.

Wupatki, located in northeastern Arizona about 40 mi north of Flagstaff, was set aside in 1924 to "preserve and protect prehistoric ruins built by the ancestors of the Hopi tribe...." It covers 145 sq km and is bordered to the north, west, and southeast by private and state land, to the south by the Coconino National Forest, and to the east by the Navajo Reservation.

Wupatki and the surrounding area is an important eagle-gathering area to the Hopi. The issue of collecting within Wupatki emerged on 27 May 1999 when a group of Hopi presented a valid U.S. Fish and Wildlife Service (USFWS) permit to harvest golden eagles and asked permission to collect in Wupatki. The district ranger temporarily denied the request. On 11 June the superintendent denied the request in a letter citing 36 Code of Federal Regulations sections 2.1 and 2.2, which prohibit taking wildlife in national park areas unless mandated by federal law and when consistent with sound resource management practices. In letters dated 17 June and 26 July, respectively, the National Park Service (NPS) intermountain regional director and acting director supported the superintendent's decision. On 12 September, the assistant secretary of the interior withdrew the NPS letters to reconsider the matter, and on 22 January 2001, the Department of Interior published a proposed rule for "Collection of Golden Eaglets by the Hopi Tribe in Wupatki NM for Religious Ceremonial Use." Also in January 2001, the Hopi Cultural Preservation Office suggested NPS consider eaglet collection in its general management planning for Navajo National Monument.

The proposed rule states: "Upon terms and conditions sufficient to prevent impairment to park resources, and upon a showing that the Tribe has a valid permit to collect golden eaglets under the Bald and Golden Eagle Protection Act, the Superintendent of Wupatki NM shall grant a permit to collect golden eaglets from Wupatki NM for religious ceremonial purposes." Before collecting may occur, a National Environmental Policy Act analysis must be done. If it determined that a harvest would have no significant impact, the Superintendent would be required to issue an NPS permit to collect an eaglet in Wupatki.

The Hopi reservation is in northeastern Arizona, but they once lived and traveled over a much greater area. According to the Hopi Tribal Council, the Hopi are traditionally associated with some 40 NPS areas, ranging from Arches National Park (northeastern Utah) to the north, Pecos National Historical Park (central New Mexico) to the east, Organ Pipe Cactus National Monument (Arizona–Sonora border) to the south, and Lake Mead National Recreation Area (Arizona–Nevada border) to the west (Table 14.1).

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Year	Activity
1999	Citadel Sink — fresh nesting material and "whitewash" but no successful nesting
2000	Citadel Sink — no successful nesting activity
2000	Doney Mountain — no successful nesting activity
2000	Citadel Wash — successful nesting (1 eaglet fledged)
2001	Citadel Sink — adult pair mating and nest-building, apparently not nesting
2001	Citadel Wash — adult pair courting and nest-building, apparently not nesting
2001	Doney Mountain — Citadel Wash pair using area

Table 14.1. Golden eagle survey summary for Wupatki National Monument and nearby areas (year 2000 records from Drost 2001).

The USFWS permit authority is the Bald and Golden Eagle Protection Act. Permit number PRT 707073 has been issued since 1985 or 1986. The 1999 permit limited the take to 40 eaglets and an unlimited number of red-tailed hawks to be taken with land manager permission in Apache, Coconino, and Navajo counties in northeastern Arizona. This is the only federal permit issued to the Hopi for the harvest of eagles. There is an Arizona permit limiting harvest to 10 eaglets and 10 red-tailed hawks.

Golden eagles are large, long-lived raptors with low reproductive potential. Their productivity is linked with breeding-season weather and abundance of small-to-medium-sized mammal prey. In the Wupatki area, breeding spans January through August or later. Females usually lay two eggs (Kochert et al. in review) and fledge one eaglet per territorial pair (Thompson et al. 1982). Golden eagles build stick nests on cliffs, rock outcrops, and large trees. They have anywhere from 1 to 14 alternate nests (Kochert et al. in review) separated by 1,000-5,000 m or more in their territory. Pairs defend their territories from other golden eagles. There is a "floating" population of non-breeding adult and subadult eaglets "waiting" for a breeding territory vacancy.

To support one breeding pair in of golden eagles in western North America, 46-251 sq km are needed (studies summarized in Watson 1997) coinciding with nearest-neighbor distances of 3.1-13.2 km. If eagle habitat in Wupatki is similar to other study areas in the West, it could support three pairs of eagles (maximum) with about 9 km between territories.

I surveyed Wupatki in 1999 and again in 2001 and Drost (2001) surveyed the area in 2000. There was evidence that eagles had visited Citadel Sink nests in 1999, but they did not raise large young and they likely did not lay eggs. In 2000, Drost found no nesting activity in Wupatki, though he did locate eagles nesting just north of the park on private land. In 2001, I observed an adult pair mating and visiting one of Citadel Sink nests and a different pair mating and flying between Doney Mountain and Drost's 2000 nest. Neither pair laid eggs in 2001. Drost (personal communication) and I believe there is little chance we missed potential breeding sites in or near Wupatki.

Drost (2001) reviewed Wupatki natural resource files and found reference to two golden eagle nest sites in the park. The Black Falls Trading Post record is vague and may represent a site on the Navajo Reservation, leaving Citadel Sink as the only known nest site in Wupatki. He summarized eagle observations in park files (Table 14.2). There are four records of eagles laying eggs from 1936-2001. An eagle was shot at Citadel Sink in 1943, and the park road was relocated to within approximately 354 m of the nest cliff at Citadel Sink in 1954. A parking lot and interpretive trail were built within 200 m of the cliff, probably after the road was relocated. The district ranger who served during the period 1990-1998 does not believe golden eagles successfully nested at Citadel Sink during his tenure, though he noted a broken eagle egg in the nest in 1995.

Year	Activity
1936	Doney Mountain — two eggs in nest
1939	Documented successful nesting
1940-43	Multiple records of eagles (including eagles visiting nests)
1943	Eagle shot at Citadel Sink
1944-51	No golden eagle record at Citadel Sink
1954	Park road built within 250 m of Citadel Sink
1992	Doney Mountain — "active" (Arizona Game and Fish records)
1995	One egg noted in nest by district ranger, eventually broken, unsuccessful attempt
1990-98	Occasional golden eagle activity noted by district ranger, no successful nesting

Table 14.2. Golden eagle records from Wupatki National Monument natural resource files (from Drost 2001).

Mark Fuller, Mike Kochert, and Loren Ayres of the U.S. Geological Survey Biological Resource Division (USGS-BRD) Snake River Field Station have written a proposal to USFWS to determine golden eagle population size and trend and productivity trend for the western USA from the western Great Plains to the crest of the Cascade and Sierra Mountains over a 10-year period. They will use August and September aerial surveys (and possibly Breeding Bird Survey data) to count and age individuals, and distance sampling to estimate density. They propose intensive radio telemetry work to determine detectability and hope to be able to age birds to estimate productivity.

USGS-BRD and USFWS dropped a radio telemetry study to determine age-specific mortality and model harvest impacts from an earlier version of the proposal. It would have helped quantify causes of mortality in northeast Arizona. Kochert et al. (in review) estimate that about three-quarters of golden eagle deaths are human-caused: 27% are due to collisions with structures or vehicles, 25% to electrocution, 15% to shooting, and 6% to poisoning. They cite anecdotal reports of noteworthy eagle mortality, including 5,000 shot in West Texas from 1941-1947, 1,000 killed by vehicles in southwestern Wyoming in the winter of 1984-1985, and 28-43 killed annually by wind turbines in California. According to USFWS, Hopi harvest reported under PRT 707073 totals 208 through 2000. There may be unreported harvest of eagles by the Hopi or others in northeastern Arizona.

Most raptor biologists consider golden eagles relatively sensitive to human disturbance, although the evidence is mostly anecdotal or correlative. Steidl et al. (1993) found adults spent less time at the nest and fed young less frequently when campers were 400 m compared with 800 m from the nest. Harmata (2001) showed adult golden eagles whose young are banded are more likely to move to an alternate nest or not breed the following year. There are no data on the effect of harvest on territory reoccupancy in subsequent years.

At Wupatki, the location of the park road, along with the presence of visitors in the parking lot and interpretive trail at Citadel Ruin, may be the reasons why there are few recent records of eagles nesting at Citadel Sink. To encourage nesting, the superintendent closed the parking lot and interpretive trail from February through late March 2001. The birds did mate at Citadel Sink and visit the nests, but did not lay eggs. The superintendent is committed to a similar closures next year to minimize potential disturbance. Wupatki staff adopted monitoring protocols to minimize disturbance risk, specifying that unlimited observations may be made from a distance, while closer observations from within a vehicle on the park road are limited to a maximum of 15 minutes.

Before NPS can make scientifically based management decisions for eagles in Wupatki and the region, important information needs must be met. USGS-BRD and NPS have gathered available information on past nesting in and near Wupatki, and NPS is committed to monitoring territory occupancy, breeding status, and breeding outcome in the future. The effects of visitors are being considered in Wupatki management. NPS must also address the effect of potential harvest on future territory occupancy: Will such harvest cause adults eagles to move outside Wupatki or not breed in subsequent years? NPS must also consider the regional population: What is the size and trend of the population that would be affected by Hopi harvest, and what are the causes of mortality that can be mitigated?

USFWS has inadequate information as a basis for PRT 707073. The agency does not know the size, trend, productivity, or geographic extent of the regional golden eagle population. It does not know the effect of harvest on breeding in subsequent years, nor the causes and importance of human-induced mortality in the region nor have they done cumulative impacts analysis.

Even though this is a contentious issue, good things are happening. NPS is more aware of eagles in Wupatki and the southwestern USA and is addressing human disturbance and monitoring the birds. USFWS is sponsoring a western-USA population monitoring study. This work and increased understanding of the magnitude of human-caused mortality may result in actions to reduce it. Everyone involved with the issue of harvest in northeastern Arizona wants to see a healthy eagle population, and there are opportunities to work together towards that goal.

Acknowledgments

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15 An adaptive approach to elk management in Rocky Mountain National Park

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Introduction

A native elk *(Cervus elaphus)* population exerts significant influence on ecosystem processes and conditions in Rocky Mountain National Park. The appropriate elk population size and associated effects on plant communities have been questioned since the 1930s. The population ranges across park boundaries, to winter in the town of Estes Park and on adjacent U.S. Forest Service land.

Elk management in the region is controversial, driven by a number of issues. Inside the park, these focus on changes in plant communities, particularly declines in willow *(Salix* spp.*)* and aspen (*Populus tremuloides* Michx.*)* that have occurred on the primary winter range over the past 60 to 70 years. Elk viewing is very important to park visitors and local residents, particularly in the fall during the mating season when there are phenomenal opportunities to observe elk in very accessible areas. In addition to the importance of the visitor experience, this raises issues regarding tourism and local economies. Other issues are related to human–elk conflicts, especially in Estes Park, including motor vehicle accidents and the impacts of elk on gardens and ornamental plants.

National Park Service (NPS) management policies (NPS 2001) direct managers to preserve natural resources and processes in an unimpaired condition to perpetuate their inherent integrity, recognizing the importance of naturally evolving ecosystems. Natural conditions are defined as those that would occur in the absence of human dominance over the landscape. Observed changes in plant communities in Rocky Mountain National Park have presumably occurred in response to both natural processes and the influence of modern humans. The challenge for managers is to determine what changes are appropriate given NPS mandates.

Humans have influenced ecological conditions in the park and Estes Valley over thousands of years. Native Americans used the area seasonally, and used game drives to harvest elk from 4,000-6,000 years ago until the late 1700s. Since 1860, when Euro-Americans settled in the Estes Valley, human land uses have included market hunting, livestock grazing, logging, fire use and suppression, agriculture, water diversions, elimination of wolves and grizzly bears, predator control, introduction of exotic plant species, development, and recreational activities. Development has continued to increase in the valley, and today there are over 10,000 residents in the Estes Park area. Elk populations in and adjacent to the park have been managed in various ways, ranging from complete extirpation and re-establishment through transplants to regulated population control and natural regulation. Given these substantial human influences, the park's statement for management (NPS 1992) recognizes that natural processes have been interrupted and acknowledges (1) the need for data to define the range of natural conditions and processes, and (2) when necessary, the need for active management to achieve this range.

The value of adaptive management is widely recognized. Defining objectives is critical to an adaptive approach. Clearly there is value in using a non-deterministic

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approach to define objectives in national parks when all key ecosystem components and processes are intact or nearly so (e.g., Yellowstone National Park). However, in the absence of an intact ecosystem, a deterministic approach for defining objectives provides an important basis to evaluate the need for changes in management direction. Accordingly, because of the lack of an intact ecosystem in Rocky Mountain National Park—especially the fact that predators are missing, combined with the significant human presence in key winter range areas—we believe measurable objectives must be defined and a management strategy to achieve those objectives must be developed.

Research

Managing natural systems requires understanding how systems functioned historically, as well as a capacity to predict the consequences of various actions. Accordingly, NPS and U.S. Geological Survey Biological Resources Division began a major research initiative in 1994 to provide critical information on existing conditions and examine the roles of several key ecosystem processes in Rocky Mountain National Park. A key part of the initiative focuses on using empirical data collected in the park to parameterize a spatial ecosystem simulation model (Coughenour 1993) that integrates various ecosystem components and processes, including elk populations, plant communities, climate, fire, hydrology, and predators, and incorporates stochastic variability. The model will provide managers with an objective decision-making tool with the means to assess natural conditions and predict the results of different potential management scenarios. A final report from the 1994 initiative is nearing completion. Results available to date, highlighted in the following paragraphs, provide some important information for managers.

After elk reductions ended in 1968, the population steadily increased to a current estimate of about 2,700-3,400 animals (Lubow et al. 2001). The population comprises three sub-herds: two that winter within park boundaries and a third that winters in the town of Estes Park. These sub-herds exhibit different population dynamics, most notably significantly higher calf recruitment and survival in the town sub-herd than the park sub-herds (Lubow et al. 2001). After 1968, the park sub-herds initially increased at an annual rate of 7% and then gradually slowed their rate of growth to reach an estimated food-limited carrying capacity of approximately 1,000 animals by 1991 (Lubow et al. 2001). The park sub-populations have been relatively stable, fluctuating around this level for 10-15 years. The town sub-population is currently estimated at 1,700-2,400 and appears to be increasing at an annual rate of 5% (Lubow et al. 2001). Preliminary food-limited carrying capacity estimates for town range from 2,000 to 3,700 animals (Lubow et al. 2001; F. Singer, unpublished data; M. Coughenour, unpublished data), making it unclear whether this sub-herd is at carrying capacity or growing.

Carrying capacity in the town area in 1996 was estimated to be only 5% less than if the area were still in a pristine condition. This is because an increase in forage quality and quantity on fertilized and irrigated pastures and lawn have largely offset the decrease in forage caused by development (F. Singer, unpublished data; M. Coughenour, unpublished data). It is expected that continued development has resulted in and will continue to contribute to further decreases in carrying capacity.

Willow growth and size in Rocky Mountain National Park appears to be primarily determined by the intensity of elk browsing, which was found to significantly reduce willow height (Peinetti et al. 2001a; Zeigenfuss et al. 2001), volume (Peinetti et al. 2001a), and the number of leaves per stem (Peinetti et al. 2001a) on the primary winter range. Elk also substantially reduced willow size over the long term, with willow volume and height being 98% greater inside a 35-year-old ungulate exclosure located on the primary winter range (K. Schoenecker, unpublished data).

Over the past 50-60 years, riparian shrub cover (primarily willow) has declined about 20% in key areas on the primary winter range. Reductions in stream sinuosity and length (69% and 47% decrease in water surface area in Moraine and Horseshoe parks, respectively), primarily due to large beaver declines since 1940, have played an important role in the decline of willow in these areas (Peinetti et al. 2001b). There has also likely been a large transition from tall-willow areas to short-willow areas. It is possible that new willow plants on much of the primary elk winter range in the park will not reach heights much greater than 1 m with the current density of elk and their level of consumption.

Aspen stands on the primary elk winter range and in the heavily browsed Kawuneeche Valley have either not exhibited aspen regeneration for over 30 years and are overmature and deteriorating, or have already been eliminated (Baker et al. 1997; Olmsted 1997; Suzuki 1997). However, on a broader landscape scale aspen stands throughout the rest of the park are successfully regenerating (Suzuki 1997; M. Kaye, unpublished data). Elk currently browse all of the young aspen suckers on the primary elk winter range. Olmsted (1997) found large trees decreased by 42%, with 40% of the stands displaying a noticeable decrease in viable mature trees. Baker et al. (1997) and Olmsted (1979) found aspen cohorts only regenerated on the primary winter range when the elk population size was estimated to be fewer than 600. With one exception, there was no evidence of suckers outside of ungulate exclosures maturing into trees (height > 2.5 m) after 1970, indicating that existing aspen stands are overmature and in danger of losing their above-ground component (Baker et al. 1997; Olmsted 1997). If current trends continue, it is expected that all of the clones on the primary elk winter range will eventually be lost, potentially indicating that the system is outside of its range of natural variability (Weisberg 2000).

Preliminary results from simulation modeling suggest that under natural conditions predation by wolves may have limited elk numbers and resulted in increased willow size and cover on the primary winter range (M. Coughenour, unpublished data). Preliminary results for aspen are mixed, ranging from a slower rate of aspen decline to different levels of long-term persistence on the primary winter range (Weisberg 2000; M. Coughenour, unpublished data).

Management Approach

Once final research results are available, an elk and vegetation management plan and environmental impact statement (EIS) will be developed to evaluate the full range of future management possibilities. Public input gained through this process will be critical to management decisions. Science will allow managers to define a range of ecologically acceptable conditions that reflect the natural variation in which the system evolved, but science will not produce a precise objective. In addition, several different methods of achieving objectives may be possible. Therefore, there will be some latitude within the indicated range of acceptable conditions for public input to guide management decisions.

We will use an adaptive approach as we proceed with elk management decisions. After objectives have been defined and a management strategy developed through the EIS process, we will implement the strategy in an experimental context, monitoring ecosystem responses and comparing them with responses that were predicted by simulation modeling. As our ecological understanding improves over time we will continue to refine our strategy. Recognizing that reintroduction or recovery of the original array of predators and the elimination of human impacts is improbable, it is expected that this will be a long-term process over many decades, and will continue indefinitely.

Discussion

Balancing ungulate populations and associated ecosystem effects is a concern in many U.S. national parks. In recent years the natural regulation policy of NPS has been questioned and the need to open dialogue recognized (Wagner et al. 1995). The natural regulation policy is often misunderstood as a strictly “hands off—let nature take its course" policy. Clearly, NPS policy allows for active management intervention to correct for human-caused deviations from natural conditions (NPS 2001). However, the way in which policy has been implemented at Rocky Mountain National Park in the past has not encouraged an active process of evaluating the need for intervention. This is largely because specific criteria for management of a naturally regulated system were not established (Stevens 1980). Clearly iterated, ecologically defined management objectives are needed (Wagner et al. 1995). Park managers are redefining how policy is implemented at Rocky Mountain National Park, with a focus on defining ranges of acceptable conditions, in specific, measurable terms.

Clearly, management is a complex endeavor, one that requires compromises and trade-offs. Differing management objectives among state and federal agencies and local communities will provide significant challenges, and solutions will require cooperation. Simulating natural processes could require active management, and some of the methods that are evaluated could be unacceptable to segments of the public. Because of the inherent uncertainties in potential ecosystem responses, a conservative approach that minimizes long-term risk may be prudent. Non-intervention may pose greater risks to park values and resources than active intervention (Berry et al. 1997). Modeling used in an adaptive context will allow evaluating risks associated with alternative actions or inaction.

It is unlikely that naturalness, as defined in terms of conditions that would prevail without human influence, will ever be achieved in a pure sense. However, by defining acceptable limits of variation in ecological processes managers can develop an operational definition of "natural" that is appropriate in a contemporary context. Ultimately, decisions will be based on society's values, as well as science. As societal values evolve, policies for management of public resources will change to reflect those values.

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16 Controlling non-indigenous vegetation at eight national parks in Virginia

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Overview

The Virginia Invasive Vegetation Management Team (VIVMT) is a project tackling invasive vegetation at eight National Park Service (NPS) Virginia Subcluster parks: Appomattox Court House National Historical Park, Booker T. Washington National Monument, Colonial National Historical Park, Fredericksburg and Spotsylvania County Battlefields Memorial National Military Park, George Washington Birthplace National Monument, Petersburg National Battlefield, Richmond National Battlefield Park, and Shenandoah National Park. The VIVMT, funded by the NPS Natural Resource Protection Program (NRPP), has had notable success in its first year of operation. This paper describes the progress and activity to date. Perhaps the greatest project benefit, beyond acres treated and documents completed, is the engendered cooperative spirit between the project team and participating parks, as well as between individual parks themselves. It is a spirit that will prove beneficial well into the future.

Project objectives

The VIVMT strives to:

- Assess invasive vegetation problems and create strategic plans at each park for invasive control, site restoration, and treatment monitoring. Incorporate ongoing assessment into planning.
- Eradicate or control targeted alien populations.
- Assist parks in conducting site restoration to achieve sustainable plant communities.
- Create a sustainable program that survives beyond NRPP funding. This must include expertise, equipment, organization momentum, and funding.

Funding source

The project is funded through NRPP resource management national funding as part of the NPS Northeast Region allotment for FY2000-2001. Support came in two allotments: $185,000 for FY2000 and $205,000 for FY2001.

Organization

The organization includes park superintendents, resource management specialists, a project manager, and the funded VIVMT crew (Figure 16.1). The integration of crew and local park staff is essential to increase field accomplishments and sustain

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organizational memory of intent and protocols. Figure 16.2 illustrates the team's organization and communication lines.

Figure 16.1. The Virginia Invasive Vegetation Management Team (l-to-r): Matthew Patterson (crew leader), Norman Forder, Zachary Bolitho, and Carolyn Davis. Shenandoah National Park photo.

Park assessments

The Subcluster began working on the cooperative project before funding at the park level was in hand (which occurred in March 2000). It was prudent to get started with initial assessments and planning before that date so that project-funded field crews had work to tackle right away. The project manager and one Shenandoah seasonal employee began conducting field visits with local park staff in September 1999. Parks supplemented field data by clarifying questions of species presence and locations. Several obtained global positioning system (GPS) documentation for precise mapping and treatments. Excellent cooperation and host-park energies kept the planning phase proceeding at a brisk pace.

The project manager led the planning effort by analyzing park-specific data, conducting prioritization analysis of identified invasives, assembling documentation of best management practices for targeted species, and gathering local staff input on zonal treatment considerations and natural and cultural resource protection concerns. Host parks ensured that the draft documents received appropriate review from the perspectives of cultural resource protection, maintenance, public safety, and ranger activities.

Each park's plan forms a rallying point to strategically address what had seemed an overwhelming situation. Indeed, each park does have a sizable invasive vegetation problem, but the process of assessing and prioritizing treatments and gathering regional best-management practices protocols has armed us to move forward. Planning created greater understanding and did not merely satisfy an administrative need (Table 16.1).

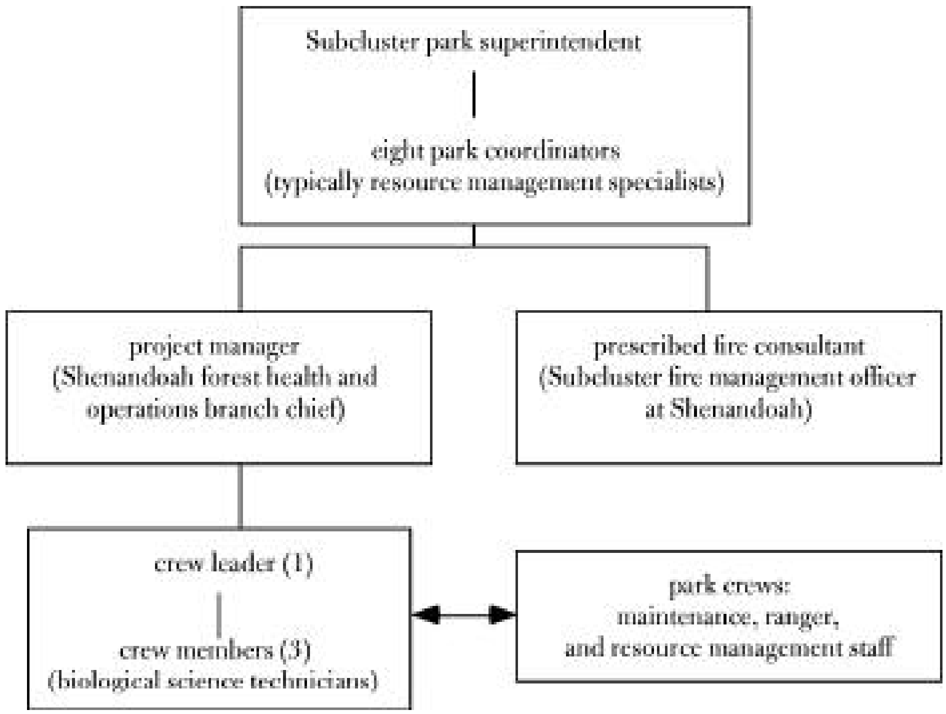


Figure 16.2. VIVMT organizational chart.

Targeted invasive species

Each park arrived at their subset of targeted invasive species through a four-tiered approach.

1. Published information from the commonwealth of Virginia *(Invasive Alien Plant Species in Virginia,* co-published by the Virginia Native Plant Society and the Virginia Department of Conservation and Recreation) provided a first cut at winnowing. Though Virginia has hundreds of non-indigenous species, certain species are known to be highly invasive and of particular threat to preserving natural and cultural resources.
2. Using field data, the NPS *Handbook for Ranking Exotic Plants for Management and Control* (Hiebert and Stubbendieck 1993) was used to correlate potential environmental impacts with potential for treatment success. Localized conditions and species-presence information is incorporated into the system. The method assesses each species according to its environmental threat potential and its current control or eradication potential. The resulting plot of species values on a four-quadrant grid allows easy comparison. The first priority for treatment are those invasives that have a high environmental threat but which are easily controlled. The second priority includes those posing high threats but with lesser control potential. The third priority pose lesser threats and have easier control potentials, while the lowest priority are those posing lesser threats coupled with lesser control potentials.

3. Species and epicenter priorities were adjusted for cultural and natural resource protection concerns.
4. Lastly, priorities were adjusted for operational practicality. For instance, certain epicenters might be combined with others to aid fieldwork efficiency, though a given one might not rank highly on its own merits.

Table 16.2 shows how species were identified and prioritized for treatment at each park.

Item / Park	*Initiated Analysis*	*First Draft Forwarded for Review*	*Final Document Approved & Published*
Strategic Plans			
Booker T. Washington	Oct 1999	4 Nov 1999	19 Apr 2000
Geo. Washington Birthplace	Nov 1999	9 Nov 1999	20 Apr 2000
Petersburg	Nov 1999	2 Dec 1999	20 Jul 2000
Richmond	Nov 1999	21 Jun 2000	5 Sep 2000
Colonial	Dec 1999	20 Mar 2000	25 May 2000
Shenandoah	Dec 1999		
Fredericksburg & Spotsylvania	Mar 2000	14 Apr 2000	2 Jun 2000
Appomattox Court House	Aug 2000	6 Sep 2000	19 Sep 2000
Treatment Monitoring Plans			
All	Dec 1999	Dec 1999	With the above
Safety Plans			
All	May 2000	Jun 2000	25 Jul 2000

Table 16.1. Strategic planning progress.

Achievements to date

- Initial field reconnaissance and assessments were completed at all eight parks.
- Strategic plans for managing alien invasive vegetation were completed and adopted at seven parks.
- Staffs charged with protecting natural and cultural resources worked together toward the common goal of reducing alien species impacts.
- Programmatic or site-specific environmental clearances were completed at all eight parks.
- On-the-ground treatments began at all eight parks, amounting to 74 acres of initial controls during five months of FY2000, with an additional 125 acres accomplished during the first six months of FY2001, for a total of 199 acres.

Park	*Targeted Invasive Species (listed in order of priority)*
Appomattox Court House	Princess tree, tree of heaven, multiflora rose, Japanese honeysuckle, Johnsongrass, Japanese stiltgrass, Japanese barberry, Chinese wisteria, bull & Canada thistles, crowned vetch, privet, mimosa tree, mulleins, periwinkle, spotted knapweed, chicory
Booker T. Washington	Kudzu, Johnsongrass, tree of heaven, Japanese honeysuckle, Japanese stiltgrass, gorse
Colonial	Princess tree, tree of heaven, Asian bamboo, privet, Japanese knotweed, oriental bittersweet, non-indigenous wisteria, Phragmites, kudzu, English ivy, Japanese honeysuckle, Johnsongrass, periwinkle, Japanese stiltgrass, multiflora rose, mimosa, wineberry, barberry, gill-over-the-ground, non-indigenous thistles
Fredericksburg & Spotsylvania	Multiflora rose, tree of heaven, Japanese honeysuckle, English ivy, periwinkle
George Washington Birthplace	Autumn olive, Phragmites, English ivy, periwinkle, non-indigenous grasses, multiflora rose, Japanese honeysuckle, giant mullein
Petersburg	Tree of heaven, Johnsongrass, privet, Japanese stiltgrass, Japanese honeysuckle, Asian bamboo, mimosa, Chinese lespedeza, multiflora rose, periwinkle
Richmond	Tree of heaven, privet, mimosa, Japanese honeysuckle, oriental bittersweet, princess tree, English ivy, Johnsongrass, Japanese stiltgrass, multiflora rose

Table 16.2. Targeted invasive species, by priority, for parks within the Virginia Subcluster.

- VIVMT specialists at all eight parks trained host-park staff. Training included botanical species identification, integrated pest management, specific control techniques, and herbicide use safety.
- Monitoring plots were established at five parks.
- Treatment site records were established for all eight parks that incorporate GPS, U.S. Geological Survey quad maps, and aerial photography imaging via ArcView. The resulting database includes directions to treatment sites and monitoring plots, field evaluation data, herbicide usage data, and ground-photography referencing. A centralized database contains all Subcluster data. From that, park-specific information in database form was transmitted to each park at the end of FY 2000, and will be again at the end of FY 2001.
- Organizational capacity was increased at all eight parks by acquiring tools for efficiently implementing invasive vegetation management and enhancing staff understanding of the program.
- Public information pieces were promulgated including op-ed news releases; television, radio, and newspaper interviews; and posters.

Park-by-park treatments

What follows are descriptions of control activities at each park within the Subcluster. Brief invasive species descriptions are in Table 16.3. These species occur virtually throughout Virginia and are merely a representation of the overall challenge.

Appomattox Court House. Documenting candidate treatment sites for monitoring and data tracking in advance of fieldwork were the highest park-driven priorities. Therefore, 2000-2001 treatment sites were set up, recorded by GPS, and documented. Pretreatment surveys were conducted at several locations. To date, field treatments of princess tree *(Paulownia tomentosa),* tree of heaven *(Ailanthus altissima),* and multiflora rose *(Rosa multiflora)* were accomplished on 5.1 acres at the park.

Booker T. Washington. Over the course of 3 four-day visits, seven invasive species were treated, totaling 39 acres at the park. Treated species include tree of heaven, mimosa tree *(Albizia julibrissen),* kudzu *(Pueraria lobata),* Japanese stiltgrass *(Microstegium vimineum),* giant mullein *(Verbascum* spp.), gorse *(Ulex europaeus),* and Johnsongrass *(Sorghum halepense).* Follow-up retreatment was accomplished on 3.1 acres of tree of heaven and stiltgrass. As part of the cooperative, the Appomattox Court House resource specialist treated 15 acres of Johnsongrass using a farm implement that wipes herbicide upon the taller Johnsongrass stalks. Herbicide for that action was furnished through project funding. As a result of the spirit of cooperation in this project, the farm implement is available for use by other Subcluster parks.

Colonial. Work focused on Jamestown Island, but Yorktown also received treatment. Seven species were treated, totaling 33 acres, during the course of 23 days over four visits to Colonial. Treated were tree of heaven, princess tree, privet *(Ligustrum* spp.), Oriental bittersweet *(Celastrus orbiculatus),* English ivy *(Hedera helix),* Japanese honeysuckle *(Lonicera japonica),* and Japanese barberry *(Berberis thunbergii).* Plans are going forward to treat kudzu on the Colonial Parkway in the spring of 2001.

Fredericksburg and Spotsylvania. Five species were controlled on 22.7 acres at the park. This took place over the course of 28 days in four visits to the park. Treated were tree of heaven, multiflora rose, Japanese honeysuckle, Oriental bittersweet, and bamboo *(Phyllostachys aurea).*

George Washington Birthplace. Autumn olive *(Elaeagnus umbellata),* privet, common reed *(Phragmites australis),* tree of heaven, and periwinkle *(Vinca major/minor)* were treated during the course of 23 days over four visits to the park. Six sites were treated, totaling 25.2 acres. Follow-up retreatments were accomplished on 0.1 acre.

Petersburg. Tree of heaven, privet, multiflora rose, Johnsongrass, crown vetch *(Coronilla varia),* silver poplar *(Populus alba),* Oriental bittersweet, and Japanese honeysuckle were treated during a period of 27 days in four visits. Eighteen sites were treated totaling 29.8 acres at the park. Follow-up retreatments were accomplished on an additional 8.8 acres.

Richmond. Eight sites were treated totaling 11.7 acres. Tree of heaven, mimosa tree, privet, autumn olive, Japanese honeysuckle, and Oriental bittersweet were treated. The VIVMT crew had 22 on-site workdays over the course of three visits.

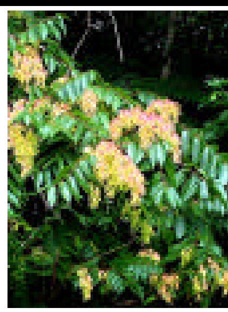
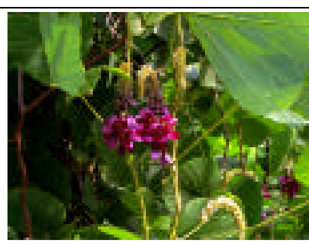
Shenandoah. Work concentrated on three species: Oriental bittersweet, princess tree, and tree of heaven. Two general areas were treated totaling 32.8 acres, including Big Meadows and the North Fork of the Moormans River. VIVMT conducted 16 on-site workdays.

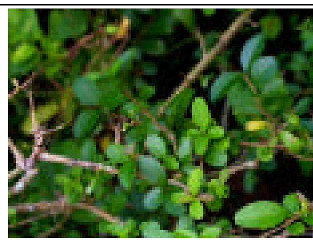
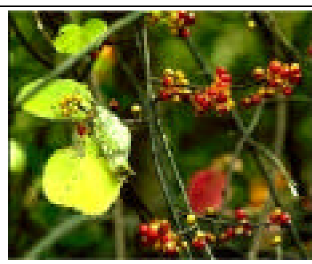
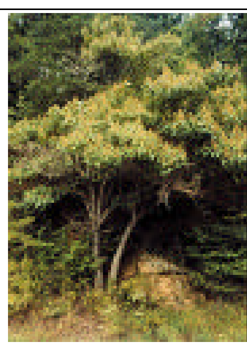
Tasks remaining for FY2001

- Complete a strategic plan for one remaining park (Shenandoah).
- Continue initial and follow-up invasive controls at all parks.

- Install additional monitoring plots at all eight parks.
- Coordinate with all parks to continue invasive controls and monitoring beyond FY2001. Continue field training of park staff in vegetation controls and monitoring protocols.

Table 16.3. Brief descriptions of some prominent invasive species in the Virginia Subcluster.

	Description
	***Tree of heaven*** *(Ailanthus altissima)* ***Distinguishing characteristics***: Large leaves, having 11-41 leaflets, not toothed except for a pair of gland-tipped teeth near bases. Bark is gray-brown, smooth or with light brown grooves. Clusters of small yellow flowers. Scent is said to resemble burnt peanut butter. Colonial National Historical Park photo.
	***Johnsongrass*** *(Sorghum halepense)* ***Distinguishing characteristics***: Large dense clumps with long smooth leaves and white mid-vein. Produces red-brown seeds. Can reach anywhere from 2 to 8 ft in height. Colonial National Historical Park photo.
	***Kudzu*** *(Pueraria lobata)* ***Distinguishing characteristics***: An aggressive vine that forms a continuous blanket of foliage. It has large leaves with small purplish pea-like flowers. This vine has the potential to grow up to 60 ft per season. Colonial National Historical Park photo.
	***Multiflora rose*** *(Rosa multiflora)* ***Distinguishing characteristics***: Leaves are 4-12 in long with 7-9 leaflets; stipules are deeply fringed. It has numerous white flowers. Colonial National Historical Park photo.

	***Common reed*** *(Phragmites australis)* ***Distinguishing characteristics***: Perennial wetland grass 3-13 ft tall. Strong rhizomes grow on or beneath the ground surface. Tough vertical stalks support sheath-type leaves near the base and tapering to a point. Foliage is gray-green during the growing season, with purple-brown seed plumes appearing by late June. Colonial National Historical Park photo.
	***Privet*** *(Ligustrum* spp.) ***Distinguishing characteristics***: Lance or oblong evergreen, opposite leaves, 1-2 in long. Tubular flowers, in dense panicles. Usually shrubby up to 20 ft tall. Colonial National Historical Park photo.
	***Oriental bittersweet*** *(Celastrus orbiculatus)* ***Distinguishing characteristics***: Shiny, green, nearly round leaves are found on dense vines. The plant's vine base is often thick and woody. Flowers are green and the berries are bright orange with a yellow sheath. J. Swearingen photo.
	***Princess tree*** *(Paulownia tomentosa)* ***Distinguishing characteristics***: Large, paired, heart-shaped leaves, velvety and hairy on the underside. The trunk is slightly rough with some smooth areas that are at times shiny. It has large clusters of purplish flowers. Colonial National Historical Park photo.

Program sustainability

Activities and expenditures of the VIVMT project are aimed at creating a sustainable program of invasive vegetation control to preserve and protect native park species and resource values. Elements of sustainability have come from (1) on-site training, (2) on-the-ground work and cooperation, (3) inter-divisional and inter-park cooperation, and (4) acquisition of specific tools of the trade. The VIVMT is equipped to conduct vegetation control and site restoration into the future. A number of acquisitions also directly benefited participating parks in an effort to out-plant organizational capacity to deal with invasives. Each park was provided an invasive management "tool kit" with application tools, safety equipment, and supplies. Each park provided input to refine the items and quantities it received.

Conclusions

The first year of the VIVMT program has been very successful. Through it we have garnered outside expertise on invasives and begun to take on the difficult job of assessing, treating, and monitoring invasive vegetation in the eight parks. We have been delighted by the enthusiasm shared within the Subcluster. Funding has allowed us to increase organizational capacity for future invasive management efforts at each park. Together, the funding, expertise, and cooperation are enabling us to create sustainable programs that are so necessary if we are to adequately control the impacts of invasives on our natural and cultural resources. The challenge of alien invasives is large. It will take a sustained campaign to reduce targeted species to manageable levels.

Reference

Hiebert, Ronald D., and James Stubbendieck. 1993. *Handbook for Ranking Exotic Plants for Management and Control.* Natural Resources Report NPS/NRMWRO/NRR93/08. Denver: National Park Service, Natural Resources Publication Office.

17 Exotic species threat assessment in Sequoia, Kings Canyon, and Yosemite national parks

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Introduction

Introduced plants can bring about significant changes in ecosystems by changing structural attributes of native plant communities (physiognomy, species composition, genetic diversity) and the processes that support them (fire, nutrient cycling, hydrology, soil erosion, decomposition) (Macdonald et al. 1988). Nonnative plants are most likely to establish themselves in areas that have both a source of seeds and that undergo repeated disturbance. In parks and reserves, these include developed areas such as roads, trails, campgrounds, pack stations, water treatment facilities and residential areas (Macdonald et al. 1988; Cowie and Werner 1993). Viable plant parts are transported to these sites via clothing, animal fur and digestive systems, vehicle tires, heavy equipment, slope stabilization materials, and wind (Hodkinson and Thompson 1997; Ridley 1930; Schmida and Ellner 1983). In natural systems, river corridors and riparian areas are especially vulnerable (Macdonald et al. 1988; DeFerrari and Naiman 1994; and others) as they are subject to regular disturbance, water is an agent of disturbance and of propagule transport and moisture is readily available (Pysek and Prach 1994). Reserve managers must be armed with baseline information if they are to stem invasions from points of initial establishment, as well as to plan and implement adaptive management strategies to control invading species.

Yosemite National Park has battled a handful of invading plant species for several decades, including St.-John's-wort, bull thistle, and woolly mullein, using staff, volunteer, and biological control efforts. In fact, there was concern regarding exotic species in the park as early as 1865 when Frederick Law Olmsted, chairman of the Yosemite Commissioners, endorsed preventing the displacement of native vegetation with "common weeds ... of foreign origin," as had occurred in "large districts of the Atlantic states" (Olmsted 1865).

Sequoia and Kings Canyon national parks are in the earliest stages of an exotics control program. Neither Yosemite nor Sequoia-Kings Canyon had geographically broad survey results available to provide a synoptic picture of existing threats, nor sufficient information on the distribution, abundance, and invasiveness of species present, to form the basis for prioritization. This information is important for targeting limited funding and maximizing control effectiveness.

Study areas

Yosemite National Park, in the central Sierra Nevada, is over 300,000 ha (748,000 acres) in size and ranges in elevation from 640 m in the Merced River Canyon to nearly 4,000 m on Mount Lyell. This large elevational gradient and topographic heterogeneity support a diverse array of vegetation types, including foothill chaparral, oak woodland, upland hardwood forest, conifer forest and woodland,

From **Crossing Boundaries in Park Management: Proceedings of the 11th Conference on Research and Resource Management in Parks and on Public Lands,** edited by David Harmon (Hancock, Michigan: The George Wright Society, 2001).

meadows, and alpine plant communities. Visitation is nearly 4 million per year, 52% of them visiting Yosemite Valley during their stay (National Park Service 2000, 3-97).

Sequoia and Kings Canyon national parks, two contiguous reserves, encompass nearly 350,000 ha (864,000 acres) on the western slope of the southern Sierra Nevada. They are administered jointly, and we treated them as one reserve in our surveys. Sequoia-Kings Canyon ranges in elevation from 400 to over 4,400 m, and there is greater representation of foothill and alpine areas. Visitation is closer to 1 million and is somewhat more evenly distributed across the roaded areas of the parks.

Objectives

Our aims were to capture the diversity, abundance, and distribution of exotic plant species in the parks; map their occurrence; summarize, from published sources, information on each species present; and categorize those species according to management priority. Additional objectives included describing patterns in the distribution of exotics and providing geographic information system (GIS) and tabular summaries of available information on species present.

Approach

Distributions of vascular plants, largely native, a few exotic, were documented previously in the parks in various data sets. These included sampling associated with vegetation mapping efforts, fire monitoring plots that document species composition prior to and several years after fire, and 0.1-ha natural resource inventory plots (Graber et al. 1993). The latter set comprises over 350 plots in Yosemite and over 650 in Sequoia-Kings Canyon. Because these data sets captured species distributions in random locations, predominantly undisturbed, throughout the parks, we chose to focus on disturbed areas along vector pathways.

We generally followed the approach of Hiebert and Stubbendieck (1993), which entails assembling information on exotic plant distributions and gathering information from published sources on species' impacts, potential invasiveness, and feasibility of control. In their approach, results are summarized along gradients of controllability and threat to categorize species for management priority. We surveyed to obtain distribution information, collected available information on species present, and considered regional distributions and expert opinion in categorizing species for management priority.

Methods

We identified likely areas of exotic establishment and then surveyed them. Targeted areas included campgrounds, developments, corrals, roads, and trails. In addition, some Sequoia-Kings Canyon surveys were done in low-elevation riparian areas, pastures, and, in one case, a historic site. Field crews defined the perimeter of target areas according to the extent of regular disturbance associated with them and made complete inventories of the exotic species inside the perimeter. Categorical data were collected on the distribution and abundance of each species within each site. We inventoried roads and trails using methods appropriate to their linear character and described characteristics for each inventory site location. Along linear features such as roads and trails, surveys were limited to the width of the disturbed area associated with the travel corridor.

We graphically compared exotic species richness across elevations, both within site types and across all sites. We used cluster analysis to compare and contrast species composition among sites.

An in-depth search was made of published sources (peer-reviewed articles, technical reports, and others) for biological characteristics (reproduction, dispersal mechanisms, etc.), patterns of invasiveness in other areas, and control techniques for each species encountered on surveys. We then weighed species attributes, local and regional distribution information, potential impacts to park ecosystems, and controllability to place species in one of four management priority categories.

Results

Survey sites were well distributed across elevations and among types of sites (Figure 17.1). A total of 95 sites were surveyed in Yosemite, 80 in Sequoia-Kings Canyon (Table 17.1). Road segments surveyed in Yosemite were a standard 1 km in length, randomly selected from mapped segments. Somewhat fewer road segments were surveyed in Sequoia-Kings Canyon, but segments were longer.

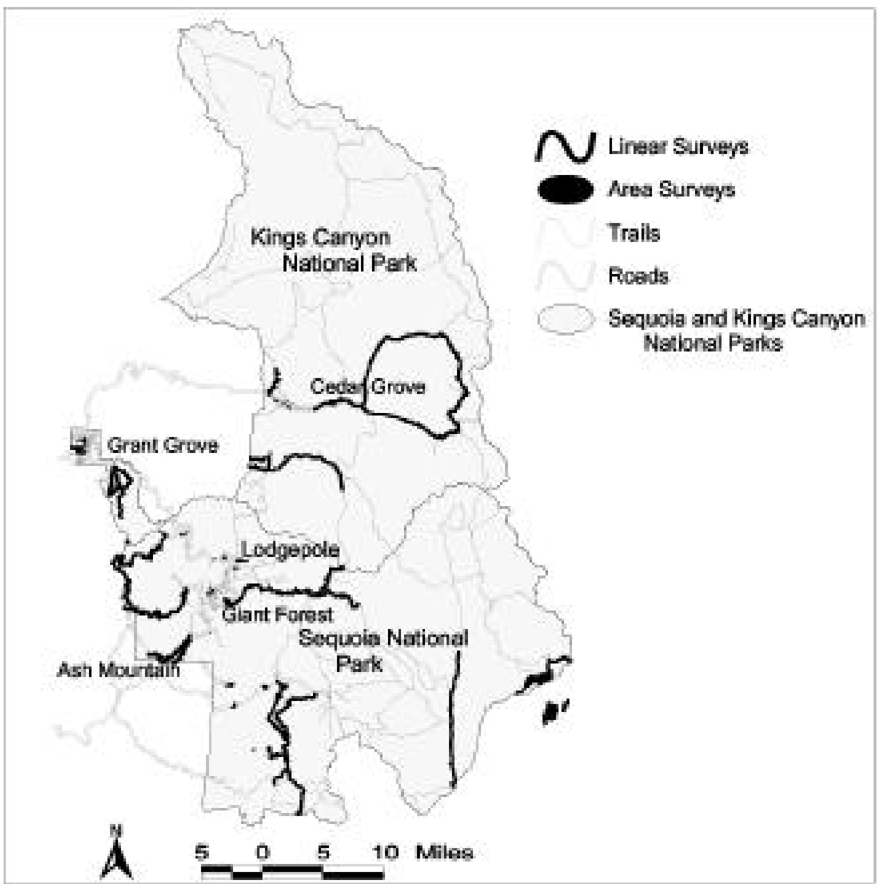

Figure 17.1. Exotic plant survey sites in Sequoia and Kings Canyon were well distributed across elevations and among types of disturbance.

Surveys documented 130 different species in Yosemite and 179 in Sequoia-Kings Canyon. There was a total of 211 exotic species encountered among the parks, with 98 species common to both Yosemite and Sequoia-Kings Canyon. Approximately the same number of species in each park (18 and 19, respectively) was listed as “most invasive” by the California Exotic Pest Plant Council (1999) or the Pacific Northwest

Exotic Pest Plant Council (1999). There were more species in developments and campgrounds than corrals and trails when all elevations were pooled.

Patch Type	*Yosemite*	*Sequoia/Kings Canyon*
Campground	14	14
Development	19	10
Corral	9	5
Road	25	8
Trail	28	26
Other	5	17
Total	95	80

Table 17.1. Number of exotic plant surveys completed in Yosemite, Sequoia, and Kings Canyon national parks between 1996 and 1999.

There was a trend of decreasing species richness with increase in elevation across all sites in both Yosemite and Sequoia-Kings Canyon (Figure 17.2). This pattern held for all sites together and for each type of site in each park. Factors that might influence this include temperature and moisture gradients across elevations, the time since species reached the parks, which species have arrived and/or level of visitation at various elevations. However, in developments, where we have extensively altered the native vegetation and thus minimized its influence, the incidence of exotics probably more strongly reflects climatic differences among sites across elevations than biotic influences.

Threat assessment

In the Hiebert and Stubbendieck (1993) approach for ranking introduced plant species for management, high priority is given to species that have a substantial impact on park resources and are easily managed. Low priority is assigned to species that cause little impact, are difficult to control, or both. Characteristics that affect controllability include extent of distribution and the existence of effective control techniques. Species life history characteristics and invasiveness in similar habitats elsewhere reflect potential for impacts to ecosystems.

Similar to this approach, we developed four management priority categories. *Category 1 species* are exotics that are currently restricted to a relatively small number of sites in each park and have either been shown to greatly affect native vegetation or have a high probability of causing serious impact. *Category 2 species* are exotics that generally have an impact on native vegetation and are restricted to a relatively small number of sites as well. *Category 3 species* are exotics that have been shown to have a great impact on native vegetation but are broadly distributed in the parks and are apparently increasing their ranges within the parks. *Category 4 species* are those species detected by the surveys but which are considered low priorities for control.

All exotic species documented during the surveys were grouped into one of the four management priority categories based on their attributes, potential impacts, and geographical extent. In addition to considering all published sources specific to particular exotic species, a number of ecological, biological invasion, weed, botanical, agronomic, and range science sources were considered in the ranking of the exotic species. Synthesis of this information provided a frame of reference to rank species for which there is little published data and to anticipate synergistic responses between species such as occurs in mixed swards of legumes and grasses.

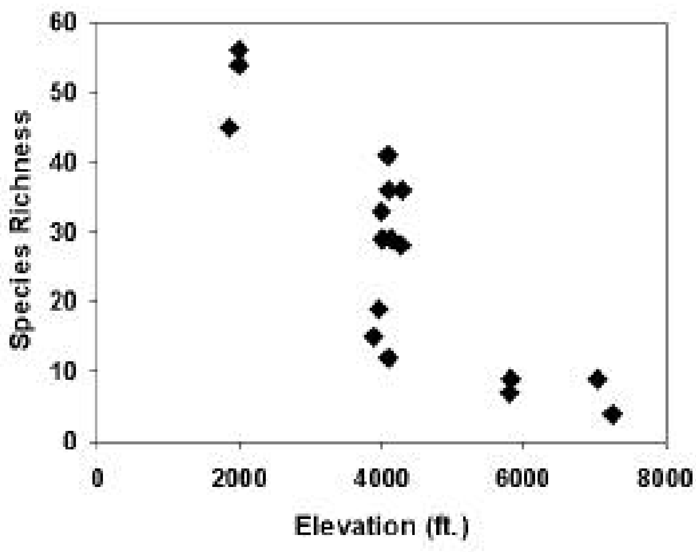

Figure 17.2. Species richness declined with elevation in developments surveyed for introduced plant species in Yosemite, 1998 and 1999.

In order to organize species by possible management strategies, we grouped them as well into tactical classes (Table 17.2). The tactical classes contain species with broadly similar ecological characteristics that may require similar management techniques or approaches. These classes are wildland species, legumes, fruit and nut species, and ornamentals. Species are further organized into grass and non-grass categories. Of the localized wildland species, 20 were placed in Category 1 and zero in Category 2. Of the broadly distributed non-grass species, both bull thistle *(Cirsium vulgare)* and woolly mullein *(Verbascum thapsus)* are Category 3 species by definition. There are nine Category 1 legumes, most of which were in Sequoia. Fruit and nut species, also mostly in Sequoia, fell into Categories 1 and 2. Of the grasses, two are Category 3 because they are listed as "most invasive" by at least one of the pest plant councils but are very broadly distributed in the parks. Both of them, Kentucky bluegrass *(Poa pratensis)* and cheatgrass *(Bromus tectorum)*, occurred in both parks. The total number of species that fell into Categories 1, 2, or 3 was 90, out of 211 species documented.

We created GIS themes from global positioning system (GPS) field data of survey locations and species distributions. These can be queried by site for a species list of the site or by species for a map of all sites where that species occurred. Information on species biology was provided in tabular form for use by park staff, in conjunction with distribution information, for planning control programs.

	Management Priority Category			
	1	2	3	4
Non-grass species				
Wildland species	20	0	2	*
Legumes	9	0	0	7
Fruit & nut species	8	5	0	1
Ornamentals	18	2	0	2
Grass species				
Wildland species	11	13	2	34

Table 17.2. Number of exotic plant species in Yosemite, Sequoia, and Kings Canyon national parks assigned to management priority categories by tactical class. Species are limited to those detected on surveys of disturbed areas between 1996 and 1999. *Note: other than legumes, fruit/nut species and ornamentals, 95 Category 4 non-grasses were species of disturbed areas, waste places, fields, roadsides, lawns or gardens. A portion may be wildland species as well.

Italian thistle *(Carduus pycnocephalus)* is an example of a Category 1 species. It was found at one site in Yosemite and nine sites in Sequoia-Kings Canyon, but has extensive distribution in the state. Vectors that spread Italian thistle include ants, hay, soil, vehicles, and wind. Seed viability is greater than 10 years and it is on the California and Pacific Northwest Exotic Pest Plant Council list of "lesser invasives."

Johnsongrass *(Sorghum halepense)* is an example of a Category 2 species. It is spread by a wide variety of means, can produce up to 25,000 seeds per plant, and has a seed viability of more than six years. It reproduces by seed and rhizomes annually and is considered highly invasive in the Pacific Northwest. Johnsongrass was not recorded in Yosemite and was found in only one location in Sequoia-Kings Canyon, but it has an extensive statewide distribution.

An example of a Category 3 species is bull thistle *(Cirsium vulgare).* It is a biennial that reproduces by seed, has high seed output, moderate seed viability and is listed as a "lesser invasive" in California and the Pacific Northwest. It is broadly distributed in both parks. It was found at over 33 locations in Sequoia-Kings Canyon and is known to be distributed in Yosemite at elevations ranging from at least 4,000 ft to over 8,000 ft at many locations. We found it at 37 locations in Yosemite.

Recommendations

Both the field data and the literature suggest that additional information and procedures may be necessary for the effective management of exotic species in the Sierra Nevada national parks. Our recommendations along these lines can be grouped into three general categories.

Surveys

- Survey all low- and mid-elevation riparian areas in the parks and survey high-elevation riparian areas near private lands or areas grazed by domestic animals.
- Survey all meadows to determine the extent of invasion (especially that of *Poa pratensis* and *Poa palustris).*

- Survey additional disturbed areas in the parks, including road and trail corridors, to further document current distributions.
- Survey boundary areas (including private lands inside the parks) to detect invasions from adjacent habitats.
- Maintain all of the survey data in a GIS.

Research

- Conduct research on the Category 3 species to determine their extent, growth rates, dispersal vectors, and impacts on native species.
- Model the invasion potential of Category 1 species.

Procedures

- Establish rapid-response procedures for exotic species management.
- Establish procedures for managing areas of natural and (especially) anthropogenic disturbances to prevent invasion by exotic species.
- Require that all pack animals used in the parks be fed certified weed-free feed.
- Eliminate grazing by domestic animals in areas invaded by non-native Kentucky bluegrass (*Poa pratensis* ssp. *pratensis*) to avoid contributing to its spread.
- Require the use of native grasses in lawns and prohibit the introduction of the herbicide-resistant cultivars now in development.

Acknowledgments

The Yosemite Fund provided financial support for the Yosemite survey and analysis work. David Graber, Sequoia and Kings Canyon national parks, had the vision to initiate and guide the survey work in those parks to address the important issue of exotic plant invasion ahead of management efforts there. Sylvia Haultain, Sequoia and Kings Canyon national parks, contributed to the initiation of this project and lent technical expertise and guidance to field crews. Botanists Graham Roy, Justin Adams, Brad Jelinek, Aaron King, and Melinda Schroeder provided invaluable field assistance in Yosemite, conscientiously, accurately, reliably, and with good humor. Dan Lubin compiled GIS themes from field data for displaying survey results.

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18 Horse-mounted sprayers: an innovative tool for backcountry weed treatment

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The 244,000-acre Badlands National Park is characterized by rugged badlands topography interspersed with a remnant of the native mixed-grass prairie that once blanketed the northern Great Plains. While visually resembling the vast prairie of the past, the park's grasslands include several species that did not greet the pioneers. These invasive plant species are the targets of the park's integrated weed management program.

The objectives of the Badlands weed management program are to:

- Prevent the introduction of new invasive plant species.
- Eradicate new infestations.
- Reduce the 8,000 acres of Canada thistle *(Cirsium arvense)* using chemical and biological controls.
- Confine and reduce the 20 acres of Russian knapweed *(Centaurea repens)* populations using chemical control.
- Reduce the 3,000 acres of common mullein *(Verbascum thapsus)* using chemical and mechanical controls.
- Reduce the field bindweed *(Convolvulus arvensis)* population using chemical control.
- Reduce Kentucky bluegrass *(Poa pratensis)*, crested wheatgrass *(Agropyron cristatum)*, and bromes *(Bromus inermis, B. japonicus, B. tectorum)* using prescribed fire during springtime.
- Complete global positioning system (GPS) mapping of targeted weeds using a standard data dictionary; monitor populations to assess effectiveness of control program.
- Monitor for invasion of new weed species, particularly leafy spurge *(Euphorbia esula)* and tamarisk *(Tamarisk ramosissima)*.
- Maintain or plant native species to prevent invasion and re-invasion by non-native species.
- Support research related to weed control, particularly control of yellow sweet clover *(Melilotus officinalis)* and halogeton *(Halogeton glomeratus)*.

Much of the park is inaccessible or poorly accessible to motorized equipment due to wilderness designation or rugged topography. As a result, efficient herbicide application has been a challenge since the weed management effort was first initiated in 1983. In the past, most backcountry herbicide application was accomplished using 5-gal backpack sprayers. For the most remote infestations, this would require a 3- to 4-hour hike into the treatment area carrying a 50-lb sprayer pack, less than an hour of spraying to exhaust the 5-gal tank, and a 3- to 4-hour hike back out. In areas that require less hiking time, it was possible for one biotechnician to apply two sprayer tanks in a workday. This application method was very inefficient and exhausting to the park's biotechnician crew, particularly in the heat of summer while wearing tyvek coveralls, nitrile overshoes and gloves, and a respirator. As a result, most of the

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park's effort was concentrated in the more accessible frontcountry areas and weeds in the backcountry were left primarily to biological control or no control at all.

In the spring of 2000, the park decided to try an animal-mounted sprayer unit called a Saddle-Light. Based on a design pioneered by Harley Bauer, the former weed supervisor in Ravalli County, Montana, the unit was field-tested and refined by Tom McClure and Hal Pearce of the Blanco Ranger District of the White River National Forest in Colorado. Numerous other people and organizations were involved in tweaking the design and making it available for distribution on a non-profit basis. Currently, it is available for sale from the White River Soil Conservation District.

For $500 plus shipping, the basic unit includes:

- Four recycled 5-gal soda canisters;
- One 5-lb carbon dioxide tank;
- A hand wand and nozzle with a 12-ft hose;
- Custom -designed panniers that are lightweight, durable, and non-absorbent;
- Extra fittings, o-rings, and other items for routine maintenance; and
- A user's guide.

You supply:

- A pack animal, capable of carrying 200 lbs, that has a good disposition, will stand, and can become accustomed to the hissing sound made by the equipment.
- A pack saddle. We use a nylon saddle and a heavy-duty cinch.
- A saddle blanket. We "dedicate" one to this use to avoid potentially contaminating all the saddle blankets with herbicide.
- A saddle bag with extra gaskets, tools, spare parts, eye-wash kit, and extra gloves.
- Herbicide.

In our experience, the Saddle-light sprayer improves our efficiency in backcountry herbicide application by about 500%, in two ways:

1) ***Quadruple the herbicide load.*** The pack can carry 20 gallons of tank mix, which is four times the amount that can be carried in a backpack sprayer. This greatly reduces the number of trips needed to transport the mixed herbicide into the treatment site. Due to the high amount of suspended solids found in natural waters in the Badlands, we do not refill in the field. However, the system is designed to allow the applicator to carry a jug of concentrated herbicide so that water can be dipped from a stream or lake to mix with the concentrate and thus refill the canisters in the field, thereby potentially eliminating the need to make more than one trip per day.
2) ***Quicker transport.*** Horses and mules walk faster than humans, so riding into the treatment area is faster than hiking in. In treatment areas that are within a half-mile of a road—which in the Badlands means generally the edges of the wilderness—our biotechnicians find it convenient to just walk in leading the pack animal. In more remote areas, they ride a saddle horse and lead the pack animal. Once near the treatment area, the saddle horse is hobbled and the biotechnician and pack animal go to work.

We found this equipment so valuable we purchased three more Saddle-light sprayers and are planning to purchase mules to dedicate to this use.

Chemical treatment is one of three methods in our integrated weed management program, and the Saddle-light is one of three chemical application methods used. In short, it is a piece of the program, but a very important piece if we are to reduce weeds in the backcountry. The Saddle-light is used primarily to maintain a 0.5-mi-wide weed-free perimeter around the Badlands wilderness area. Over time, we hope to increase the width of the perimeter and begin treating more interior wilderness areas. For the present time, this perimeter control strategy helps address the concerns of park neighbors as well as state and county weed officials because fewer than 1% of Canada thistle seeds travel more than 0.5 mile. The Saddle-light sprayer is also used to treat weeds in prairie dog towns to improve habitat for the federally-listed black-footed ferret that has been reintroduced in the park. Most of the reintroduction effort has been concentrated in the Badlands wilderness area. Prairie dogs are unable to clip Canada thistle stems after they become woody, thus limiting sight distance for them and potentially harboring predators. The success of the ferret population is dependent upon a healthy prairie dog population, so the Saddle-light sprayer is used for endangered species habitat improvements. The Saddle-light also is used on a more limited basis to treat weeds in non-wilderness areas where the steepness of the terrain makes all-terrain vehicle (ATV) use unsafe and in highly visible areas where the use of ATVs would interfere with the visitor experience.

For purchase or additional information on the Saddle-light sprayer, contact: Hal Pearce, U.S. Forest Service, White River National Forest, Blanco Ranger District, 317 East Market, Meeker, Colorado 81641.

19 Crossing boundaries at Haleakala: the struggle to get improved quarantine protection prior to expansion of Maui's airport

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The Park Service will be given as much opportunity to comment on the EIS as any other member of the public.

— David Welhouse, Federal Aviation Administration airport planner, quoted in *The Maui News*, 7 May 1996

I had been superintendent of Haleakala National Park for little more than a year when on October 23, 1989, Lloyd Loope, a research scientist, briefed me about plans to expand Maui's airport to accommodate international flights. The $250-million expansion project and perceived economic benefits had widespread support from the Federal Aviation Administration (FAA), the governor of Hawai'i, state legislators, the Hawai'i Department of Transportation (HDOT), the Maui mayor, and business. They eagerly anticipated Maui-to-Japan direct flights. Loope said that without better alien species prevention measures, the project would expose Maui to a greater quantity of biological invaders and new sources of origin. He stated that because oceanic island ecosystems are so susceptible to invasions and because Maui has such a diversity of habitats in close proximity to the airport, the project would result in severe ecological consequences for the park. In my daily notes I wrote apprehensively: "Not so sure I want to get involved!"

What business did the National Park Service (NPS) have concerning itself with this issue? The airport is 15 miles from the park boundary.

On the other hand, it was logical to ask: "What about NPS protection laws like the Organic Act and the Redwood Amendments? How about the National Environmental Policy Act and the Endangered Species Act?"

All that Haleakala wanted was better invasive species inspection and interdiction practices for an airport quarantine system that Loope characterized as a leaky sieve. NPS in Hawai'i was the leader in effectively dealing with goats, pigs, mongooses, and a myriad of non-native plants and insects. Park and university scientists had ample evidence of ecosystem destruction by alien species, as well as evidence that an average of 20 new immigrant insect species become established in the Hawaiian Islands annually. Furthermore, extraordinary numbers of Maui citizens were concerned about alien invasion, as well as other environmental impacts that come with an international airport. I signed and mailed the letter Loope had drafted and followed up by testifying at the Maui County Council General Plan meeting in which the airport expansion was discussed.

Fast-forwarding to today, April 17, 2001, nearly 12 years later, the airport project remains on hold pending the implementation of a seven-agency memorandum of understanding including an alien species prevention plan. The governor has deferred the runway extension. We had set out to effect implementation of state-of-the-art procedures to filter out invasive aliens, the number one nemesis of endangered Hawaiian native ecosystems. Our cause was helped because invasive alien species pose major threats to agriculture and tourism as well (Deleon 1990). How did we get to this point and what will be the ultimate outcome?

From **Crossing Boundaries in Park Management: Proceedings of the 11th Conference on Research and Resource Management in Parks and on Public Lands,** edited by David Harmon (Hancock, Michigan: The George Wright Society, 2001).

Beginning in 1989, Haleakala staff began aggressively communicating with county, state, and federal agencies to ensure that the Kahului Airport improvements project would be environmentally benign, causing no significant adverse impacts to Haleakala ecosystems. Haleakala staff testified at hearings of the Hawai'i Land Use Commission, Maui County Council, and Maui Planning Commission, and produced numerous letters to express concern and offer advice. We argued that the airport expansion plan would permit aircraft from foreign countries to arrive in ever-increasing numbers and thus expose Maui to more alien species. We argued that an international airport in Maui, with its higher-elevation habitats, would facilitate establishment of species likely to threaten the park. Additionally, we argued that whereas new immigrant insects might tend to be blown out to sea by the trade winds at Honolulu International Airport, they would be blown inland at Kahului.

Partly on the strength of NPS concerns, the state's initial two-volume environmental impact statement (EIS) was invalidated by a Hawai'i Circuit Court 1991 ruling, requiring the preparation of a federal EIS (Hawai'i Dept. of Transportation 1992).

In a September 7, 1993, letter to the FAA, the lead agency, we requested participation in the federal EIS process as a cooperating federal agency. FAA informed NPS that this request was denied because the park was 20 miles away and endangered species are the jurisdiction of the U.S. Fish and Wildlife Service (USFWS). The response included no attempt to address the points raised in the NPS letter. Applicable federal laws protecting national parks that NPS cited were ignored by FAA without so much as a word of explanation or analysis.

In March 1996 the draft EIS was released to the public. At no time before then did FAA contact Haleakala or the park's National Biological Service (NBS; now the U.S. Geological Survey Biological Resources Division, (USGS-BRD) research scientist for information on potential impacts to the park. The draft EIS did not address the NPS concerns. Instead, the FAA's airport planner responded with the quote which heads this article.

The day after that quote appeared, May 8, 1996, a public hearing was conducted. According to *The Maui News*, "of the 64 people who testified ... six spoke favorably of the draft EIS, three testimonies were unclear on the issue and the remaining 55 blasted it as being totally inadequate. By far, the most frequently cited complaint about the EIS was its treatment of alien species introductions and their potential effects on Haleakala National Park" (Hurley 1996).

The regional environmental officer for the U.S. Department of the Interior (USDI), Patricia Port, submitted USDI comments on the draft EIS that expressed NPS and USFWS concerns about the project. Port made strong recommendations that NPS concerns be addressed; if they were not, USDI would make a referral to the president's Council on Environmental Quality (CEQ).

In 1993, the park had suggested that a biological assessment (BA) was in order even though USFWS did not initially make this request. In USDI's comments on the draft EIS, Port also stated that a BA should be prepared to assess the impacts to threatened and endangered species. Faced with USDI's compelling comments, FAA called for a meeting on June 6, 1996, with the NPS, NBS, and USFWS. Attendance by Regional Director Stanley Albright and Pacific Islands Support Office Superintendent Bryan Harry added credibility to Haleakala's stand. Mention was made for the first time by the transportation agencies that it might be possible to use airport funds for mitigation of the alien species threat. As a result of this meeting, the FAA decided it would prepare a BA.

In September 1996, the FAA selected members to serve on a biological assessment technical panel (BATP) to advise USFWS and FAA during the BA drafting process. Included on the panel were Loope and me. The BA's scope of work retained the language of the draft EIS, stating: "The proposed project in itself will not have a direct impact on the introduction of non-native (alien) species, or the endangered species within the airport boundaries..."—still ignoring NPS concerns. However, in the ensuing meetings, much substantive information was revealed about the impact of alien species and airport front-line quarantine officials' concerns about severe current understaffing and the need for accommodating additional flights.

Loope and I believed the mitigation measures agreed to by the FAA were largely ineffective. The measures were non-contractual and unlikely to intercept alien species arriving aboard foreign and domestic flights. The members of the BATP were excluded in the preparation of the recommendations for mitigation listed in the BA. Recommendations were left to the discretion of the transportation agencies, without asking for BATP review or comment. The BA was submitted to USFWS, which negotiated in private the final mitigation measures it would accept in exchange for a "no jeopardy" opinion.

It is unclear why USFWS rendered a "no jeopardy" biological opinion in view of the weak mitigation measures offered by the FAA. Later it was revealed that USFWS's major consideration was what the agencies could accomplish rather than what was necessary to make "no jeopardy" a reality. It was clear to NPS that the inadequate current anti-alien species system at Kahului Airport would not be substantially improved by the proposed mitigation measures.

On October 31, 1997, the final environmental impact statement (FEIS) was released for comment. NPS was still not satisfied that enough mitigation had been committed to justify moving ahead with the project. Pursuant to Part 1504 of Title 40 of the Code of Federal Regulations, Haleakala submitted a "CEQ referral" up through the ranks of NPS to the USDI. The complainant agency has 25 days to prepare and submit the referral to CEQ. To reduce interagency confrontation and facilitate a solution to the impasse, CEQ intervened, recommending that the involved agencies resolve the issues with CEQ oversight but not under the procedures required by statutes. So NPS did not make a formal referral to CEQ. How the avoidance of CEQ deliberations and legal decisions affected the outcome will never be known.

Periodic teleconferences over a year's time, involving four state and three federal departmental agency's representatives, were coordinated by Molly Ross, a special assistant to the assistant secretary of USDI. After much negotiation, a "Memorandum of Understanding (MOU) Regarding the Prevention of Alien Species through [sic] the Kahului Airport" was produced and signed in August 1998 by responsible officials in the federal Departments of Agriculture, Interior, and Transportation and Hawai'i Departments of Agriculture, Health, Land and Natural Resources, and Transportation.

The document was a compromise which fully satisfied no one but which, as part of the final "record of decision," allowed the project to proceed while suggesting positive measures for vastly improving quarantine procedures. An appended letter from an FAA administrator documented that "airport funds" can be used for all invasive species prevention activities as long as these activities take place on airport grounds and are part of airport operations. Nevertheless, funding the various mitigation measures is a perpetual bone of contention.

In August 1998, the record of decision including the appended MOU and an alien species action plan was released. It reiterated the finding of the FEIS that "the proposed project will not significantly affect Haleakala National Park."

The MOU established a Kahului Airport Alien Species Prevention Team (ASAP) comprising official and non-official representatives, co-chaired by HDOT and the Hawai'i Department of Agriculture (HDOA). The team first met in October 1998, with meetings thereafter at intervals of one to three months.

Implementation of the alien species action plan has been slow. Some of the greatest setbacks have been due to:

- A conceptual recognition, to some extent used as a excuse for not doing anything, that improving quarantine measures at Kahului are not necessarily going to help the entire state;
- A tendency for the HDOT to drag its feet because of concern about costs;
- Negative reaction among some team members to a legal petition challenging the FEIS that was filed with the Federal Court of Appeals, Ninth Circuit, by the National Parks and Conservation Association (NPCA) and others in February 1999; and
- A concern by the airlines serving Hawai'i about additional costs to them because of the Kahului ASAP and precedents it might set. The airlines were concerned that (a) airport landing fees, a major source of airport funds, would be increased in Hawai'i; (b) revenue from duty-free shops in Hawai'i would decline, which in recent years had contributed a major source of airport revenues; and (c) delays in passenger off-loading would result from increased quarantine efforts to protect Hawai'i.

In the beginning there was every reason for HDOT and FAA to believe they could get by without major concessions for addressing invasive species issues. The NPS Organic Act and Redwoods Amendment never were addressed in the EIS process or by the litigants in the NPCA legal challenge, for NPCA felt that this was not the case to test the legal potency of these statutes. On the other hand, the NPS position was no doubt buoyed by strong and broad public concern among Mauians about invasive alien species introductions (even among many runway extension proponents). The invasive species issue was used advantageously by a strong anti-growth faction in the Maui environmental community to bring runway expansion to a standstill.

Newspaper articles about the discovery of snakes, reptiles, and new insects that evaded the almost non-existent inspection program provide periodic reminders of the problem. In its mission to protect mainland agriculture (with special emphasis on keeping fruit flies out of California), the U.S. Department of Agriculture (USDA) uses sophisticated x-rays to discern organic matter in all outgoing luggage and carry-on bags. The contrast is striking between the relatively well-funded and equipped USDA program to protect the mainland from Hawai'i and the poorly funded state programs.

A hearing on the NPCA challenge to the FEIS was held in Honolulu by the Ninth Circuit Court of Appeals in December 1999. Then, in January 2000, Hawaii Governor Benjamin J. Cayetano announced that he was withdrawing his administration's proposal for expansion of the Kahului runway. Subsequently, the three-judge ruling was 2 to 1 in favor of the defendant, HDOT. How much the court's opinion was influenced by the governor's action is open to question. NPCA filed an appeal for reconsideration, which was denied by the court. Likewise, in a suit filed in 2001 by Hui Alanui O Makena, et al. before the 2nd Circuit Court of Hawai'i, the court ruled that the FEIS was adequate. An appeal to the State Supreme Court has been made, but as of this writing there has been no ruling.

So, after eleven-and-a-half years of meetings, teleconferences, reams of paper expended, interagency friction, and millions of dollars spent on environmental compliance and legal costs, what has been gained? Unfortunately, not one sustained action has been implemented so far to keep alien species from becoming established on Maui and in Haleakala National Park. However, the Kahului Airport controversy has had a major educational effect because it has thrust invasive alien species concerns into the public arena. An excellent video has been produced to educate airline passengers as a deterrent to willful or inadvertent alien species introductions. A reinforcing informational handout to accompany the standard agricultural declaration form has been produced and is ready to go. That these are not mandatory is symptomatic of major weakness of the ASAP.

A concept we want to promote is federal appropriations and authority for domestic quarantine protection for Hawai'i — as has long existed (since 1912) to protect mainland agriculture from Hawai'i's pests. An act of Congress would be required, but seems potentially doable if the state pushes for it. It is difficult to speculate on the final outcome, but we believe that pressure from Haleakala National Park and Maui can catalyze programs to give Hawai'i the protection it needs to deal with the increasingly worldwide invasive species problem.

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20 Bighorn sheep restoration in Badlands National Park, South Dakota: lessons for cooperation

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Introduction

Badlands National Park is located in western South Dakota and consists of three units totaling more than 240,000 acres (Figure 20.1). The North Unit includes the Pinnacles area to the west, located within the 64,000-acre Sage Creek Wilderness Area, and the Cedar Pass area to the east. Much of the north unit is bordered by the Buffalo Gap National Grassland, which is administered by the U.S. Forest Service (USFS). To the south, the Stronghold and Palmer Creek units are located within the Pine Ridge Indian Reservation. These units are managed under a cooperative agreement between the Oglala Lakota and the National Park Service (NPS).

Figure 20.1. Badlands National Park, South Dakota. Shaded areas represent badlands formations. Dotted line represents Pine Ridge Indian Reservation boundary. Solid lines represent roadways or park boundaries. Ellipses represent bighorn sheep sub-populations.

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The badlands are the remains of an ancient flood plain eroded by the White River for thousands of years. Elevated sod buttes, deep gorges, and badlands pinnacles characterize the landscape and separate the upper and lower mixed-grass-prairie steppes. Grass species common on the steppes include western wheat *(Agropyron smithii)*, needle-and-thread grasses *(Stipa comata* and *S. viridula)*, blue grama *(Bouteloua gracillis)*, and buffalo grass *(Buchloe dactyloydes)* (Batt 1991). Slumps, created by erosion undercutting large portions of sod buttes that slid downslope relatively intact, are important harbors of scattered juniper stands *(Juniperus scopulorum* and *J. horizontalis)*, water, and wildlife. Ponderosa pines *(Pinus ponderosa)* occur on some elevated sod buttes and cottonwoods *(Populus deltoides)* are found along the drainages.

The climate is characterized by long, cold winters and hot, dry summers. January is the coldest month and July the hottest, with 40-year, mean-maximum temperatures of -15.1 and 32.5 degrees Celsius, respectively. Mean annual precipitation is 39.6 cm.

Past

Bighorn sheep management at Badlands began in 1964 when 22 Rocky Mountain bighorn sheep *(Ovis canadensis)* from Pikes Peak in Colorado were introduced into a 370-acre enclosure in the Pinnacles area. This was the result of a cooperative effort with the South Dakota Department of Game, Fish, and Parks (SDGF&P). The goal was to establish a captive-breeding program from which translocations could be made to several areas of suitable habitat in South Dakota within and outside the boundaries of Badlands (Hjort and Hodgins 1964). In 1967, after a number of difficulties with the health of the sheep and a final loss of 13 individuals attributed to *Pasteurella*, 14 sheep were released to the greater badlands ecosystem (Hazeltine 1967).

NPS management activities from 1967 to 1987 consisted of opportunistic observations by park personnel and a single, one-week ground count of the Pinnacles area in 1980. During this survey, a minimum of 27 sheep were observed—eight rams, nine ewes, two yearlings (one male and one female), and eight lambs (McCutchen 1980).

In 1987, at the initiation of SDGF&P, NPS entered into a memorandum of understanding to complete a research study of the bighorn sheep population. The goals were to determine the status of the population and identify the feasibility of translocations to other areas in South Dakota while ensuring the continued survival and stability of the badlands population (Badlands National Park 1987). As the lead agency, SDGF&P assumed the majority of the financial, personnel, and equipment expenses for the study. A total of six sheep were radio-collared and periodically monitored through 1990. In 1990 the population, estimated at 130 to 200 individuals, was healthy and expanding. Recommendations included continuing monitoring with an emphasis on lamb production and recruitment and additional sampling for determining the population's genetic structure (Benzon 1992).

In 1991, a multi-park bighorn sheep restoration initiative, funded by the NPS Natural Resource Preservation Program and under the direction of Francis Singer, was initiated. Representatives from NPS, the Oglala Sioux Parks and Recreation Authority, the National Biological Service (now the U.S. Geological Survey Biological Resources Division), USFS, SDGF&P, and several universities were instrumental in the planning and implementation of the initiative at Badlands National Park.

In February 1992, in partial fulfillment of the intent of the 1964 cooperative agreement and based on a study completed by SDGF&P, four ewes and one ram were removed from the Pinnacles sub-population and translocated to Spring Canyon in the Black Hills. This translocation of sheep however, actually marked the beginning of a deteriorating relationship between Badlands National Park and SDGF&P. And although department employees individually participated in Badlands management activities, the agencies ceased to actively work together on bighorn sheep management issues—the implications of which became apparent later on.

During the same capture, 19 sheep in the Pinnacles sub-population and seven in the Stronghold sub-population were sampled and radio-collared. Data were collected on home range, habitat utilization, demographics, foraging ecology, disease ecology, and genetics (Singer and Gudorf 1999). One outcome of the 1991 initiative was the development of a habitat suitability model. The model suggested that the habitat could support three to five times the number of sheep that presently occupied the range. Several areas within the park were identified for restoration, and the recommendation was to establish a meta-population of sheep within the greater badlands ecosystem (Sweanor et. al. 1995).

In 1996, relying on a 1994 survey which estimated the Pinnacles sub-population to be within the estimated carrying capacity of 90 to 170 individuals and in a healthy and expanding state, a plan was developed to guide the restoration of sheep into Cedar Pass (Runge 1996). And in October 1996, 16 sheep were captured in Pinnacles and translocated to Cedar Pass. The translocation consisted of three young adult rams, one yearling ram, eleven adult ewes, and one ewe lamb.

In October 1998 and March 1999, 16 sheep were radio-collared in the Pinnacles and Stronghold sub-populations for disease sampling and population monitoring. This came about as a result of a die-off of ewes in Cedar Pass in 1997 and the observation of fewer-than-expected numbers of ewes in the Pinnacles during the 1996 translocation.

Since then, monitoring has focused on opportunistic observations of individuals in all sub-populations outside of the lambing and rutting period. Intensive observations of radio-collared ewes are completed during May and June to estimate lamb production, survival, and recruitment. Intensive observations of all radio-collared individuals during the rut gives further information on survival and recruitment and the distribution of the rams between the three sub-populations.

So, where are we now?

Present

The population of bighorn sheep in Badlands National Park is currently composed of three sub-populations: Pinnacles, Cedar Pass, and Stronghold. Fifty-four individual sheep were observed in a ground survey in November 2000 and the population was estimated to be 58-74 individuals (Table 20.1). Cedar Pass accounted for 23, Stronghold for 5-12, and Pinnacles for three resident ewes, yearlings, and lambs with an additional 26-36 mature rams. While the mature rams were observed in all three areas, they are not necessarily associated with an individual sub-population. Past observations indicate that the majority of the mature rams summer near Hay Butte in the Sage Creek Wilderness Area and, while some rams winter in Cedar Pass, all usually leave the area by the beginning of April. There are a few rams resident in the Stronghold.

Based on mean estimates, mature rams account for 47%, adult ewes for 23%, yearlings for 8%, and lambs for 22% of the population. These results indicate that we have a population skewed towards rams by approximately two to one. The very high lamb-to-ewe ratio would normally indicate an increasing population. This value, however, reflects the high productivity and recruitment observed in Cedar Pass and the recent loss of four radio-collared ewes, three in the Stronghold and one in Cedar Pass. All those yearlings and adults observed during the survey for which health could be assessed were judged to be in good condition, with the exception of one two-year-old female that was in fair condition. The lambs all showed excellent body condition.

So, where do we go from here?

	Pinnacles	Cedar Pass	Stronghold	Totals
Rams	21-27	1	4-8	26-36 (47%)
Ewes	2	9	3-6	14-17 (23%)
Yearlings	0	4	1	5 (8%)
Lambs	1	10	2-5	13-16 (22%)
Totals	24-30	24	10-20	58-74

Table 20.1. Present bighorn sheep population estimate from fall 2000 survey. Single numbers represent absolute counts of known individuals. Ram numbers reflect the sub-population that defines their summer range and not the distribution observed during the survey.

Future

The recommended goal is to have a healthy, stable meta-population of bighorn sheep in the greater badlands ecosystem with high potential for long-term viability. A meta-population is desired to reduce the effect of stochastic disease events, maximize genetic resources, and provide source stock for translocations. This means establishing a minimum of 300 to 400 sheep dispersed between the suitable habitat areas within the park (Gross et. al. 1999). The prospects are bleak for the present population to expand into all available habitat and grow to the desired levels in the very near future, so Badlands management has the responsibility to intervene and assist.

Given the current situation, future plans for bighorn sheep management at Badlands center around additional translocations. These would effectively increase the founder size and enhance the long-term persistence of the population (Singer et. al. 1999).

In 1997, Singer submitted a grant proposal to Canon, Inc., and the National Park Foundation; as a result, $35,000 was received in 1998 to assist with the expenses of two additional translocations of 25 animals each from external source herds to Badlands. In the fall of 2000, this was supplemented with an additional $50,000 from the new Biological Resources Management Division of NPS.

So, how do we achieve our recommended goal?

Herein lies the problem with the lack of active cooperation between Badlands and SDGF&P. In 1998, a request for sheep was sent to the Colorado Division of Wildlife, with initial favorable results for 2000 or 2001. A requested letter of endorsement from SDGF&P was, however, less supportive, and it became clear that SDGF&P was also looking for sheep. This left the park in a vulnerable position when the Colorado Division of Wildlife made it clear that Badlands would not get sheep without unqualified support from SDGF&P.

During 1999, biologists and managers in all the western states and provinces having Rocky Mountain bighorn sheep were contacted regarding the availability of sheep for translocation to Badlands. A source of sheep was identified in Alberta. The source herd was infected with contagious ecthyma, however. Given that the Badlands population is currently free from contagious ecthyma, the decision was made to wait an additional year to see if a source population from Colorado was a possibility.

At this point it was clear that the approach to bighorn sheep management at Badlands National Park had to change and that change had to include cooperation with SDGF&P. And while neither agency was openly unreceptive, there had been a lack of communication regarding bighorn sheep management both in and outside of the park boundaries—we knew little about their populations and future plans and they, in turn, knew little about ours.

Plans were made to organize a meeting in the summer of 2000 between SDGF&P biologists and managers and the new Badlands resource management team scheduled to be in place in late 1999. During this meeting it was clear that both agencies shared a common vision: that of more sheep on the mountain in the form a healthy, stable meta-population of bighorn sheep in western South Dakota. In this vision, all populations, including those in Badlands National Park, were part of the larger meta-population. The question remained of how to get there when each agency was actively seeking sheep for translocations and considered its needs to be more important than the other's.

Vision

The first priority should be the development of a management plan for bighorn sheep in Badlands National Park. Development should primarily be the responsibility of NPS but should also include representatives from SDGF&P, the Oglala Sioux Tribe, USFS, and other research professionals.

This should be a comprehensive plan that outlines, at a minimum, short- and long-term goals, means and methods of achieving these goals, and basic monitoring and sampling activities. Research needs to guide management should be identified and prioritized. The plan should also address the issue of how the population will be managed once size goals have been met. Without such a comprehensive management plan, bighorn sheep management will likely continue to be reactionary in nature, research needs continue to be unmet, and restoration delayed.

The second priority should be to include this plan in a larger, long-term management plan for bighorn sheep in western South Dakota. Included should be a statewide restoration plan identifying suitable habitat and prioritizing restoration areas. Some of these areas will be outside the boundaries of Badlands National Park and some will be inside. Some existing populations may need to be supplemented. As part of the restoration plan, we need to recommend source populations for individual translocations. There will undoubtedly be different needs for different supplements and translocations. Some situations will require indigenous, external-source populations. In others it may be appropriate to supplement the Badlands population with sheep from the Black Hills, and vice versa. Recommendations should be made for post-release monitoring. These may also vary by translocation.

This may sound overwhelming. However, it is clear in this situation that we cannot continue to act independently of one another. It is time to cross the boundaries, combine resources, and share knowledge to achieve the larger goal. Steps have been made in this direction. Badlands staff recently began to participate in the Northern Wild Sheep and Goat Council symposia, and last year volunteered to co-host the 2002 symposium with SDGF&P. At the July 2000 meeting, SDGF&P presented Badlands with the beginnings of a management plan for our review. Notably, the plan included the park population as part of a larger meta-population in western South Dakota. Work was delegated and assignments made to track down source populations of sheep that could meet both our immediate needs. Knowledge was shared and agreements made to work more closely on bighorn sheep management issues in the future.

Working together, I believe we can realize our shared vision: that of more sheep on the mountain in the form of a healthy, stable meta-population of bighorn sheep in western South Dakota.

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21 Jumping the gun: island fox recovery efforts at Channel Islands National Park

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Channel Islands National Park is currently implementing aggressive, expensive long-term recovery actions for the island fox *(Urocyon littoralis)*, a species that is not currently listed as endangered or threatened under the federal Endangered Species Act. Even so, the imminent threat of extinction for three subspecies of island foxes mandates that the National Park Service (NPS) manage this functionally endangered species with the resolve and the resources usually reserved for listed species, but without access to any funding source for long-term, large-scale natural resource projects.

The island fox is the smallest canid in North America. Adults weigh approximately 2.0 kg and are a third smaller than their mainland progenitor, the gray fox *(Urocyon cinereoargenteus)*. The island fox is one of the most geographically restricted canid species, being found only on the six largest of California's eight Channel Islands. Both genetic and morphological differences among the island populations support the differentiation of the species into six separate subspecies, one on each island where the fox occurs. Within the park, island foxes occur on San Miguel Island (3,865 ha), Santa Rosa Island (21,600 ha), and Santa Cruz Island (24,314 ha).

Decline of island foxes on the northern Channel Islands

Island foxes have typically existed at small population sizes of 100 to 1,000 individuals. Total population for the species in 1994 was approximately 6,000 adults (Roemer et al. 1994). Current population size is less than half that, and island foxes have declined by over 90% on four of six islands (Figure 21.1; Coonan et al. 1998; Roemer 1999; Timm et al. 2000; Coonan 2001). Only 17 island foxes remain on San Miguel Island, and all but one are in captivity. Likewise, there are 21 foxes in captivity on Santa Rosa Island, and only one left in the wild.

On Santa Catalina Island, which is not in the park, island foxes declined by over 90% on the eastern portion of the island due to an outbreak of canine distemper virus, probably vectored to island foxes by domestic dogs (Timm et al. 2000). On the northern Channel Islands, predation by golden eagles *(Aquila chrysaetos)* is likely responsible for the massive population decline. The evidence for the importance of eagle predation comes from two studies that bracket the period of decline. In 1994-1995, Roemer (1999) found signs of eagle predation at 19 of 21 island fox carcasses on the western end of Santa Cruz Island, and during that time period the study population declined from 35 foxes to zero.

NPS conducted a radio-telemetry study on San Miguel Island in 1998-1999 to directly determine mortality factors for island foxes. Within four months of the study's inception, six of eight radio-collared foxes had died, and four of those deaths were attributed to eagle predation (Coonan et al., in prep.). Cumulative survivorship over the year-long study was approximately 10%.

Golden eagles have not historically bred or wintered on the northern Channel Islands. Golden eagles were first sighted on the islands in the mid-1980s and the first nesting record was in 1999 (Roemer 1999). Their increased presence is due to the

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existence of a substantial non-native prey base, feral pigs, and the recovery of mainland golden eagle populations following decades of persecution. Also, bald eagles *(Haliaeetus leucocephalus)* historically bred on the Channel Islands but have been missing since the 1950s due to persecution and the effects of organochlorine pesticides (Kiff 1980). Breeding bald eagles are highly territorial and may have prevented golden eagles from establishing breeding territories.

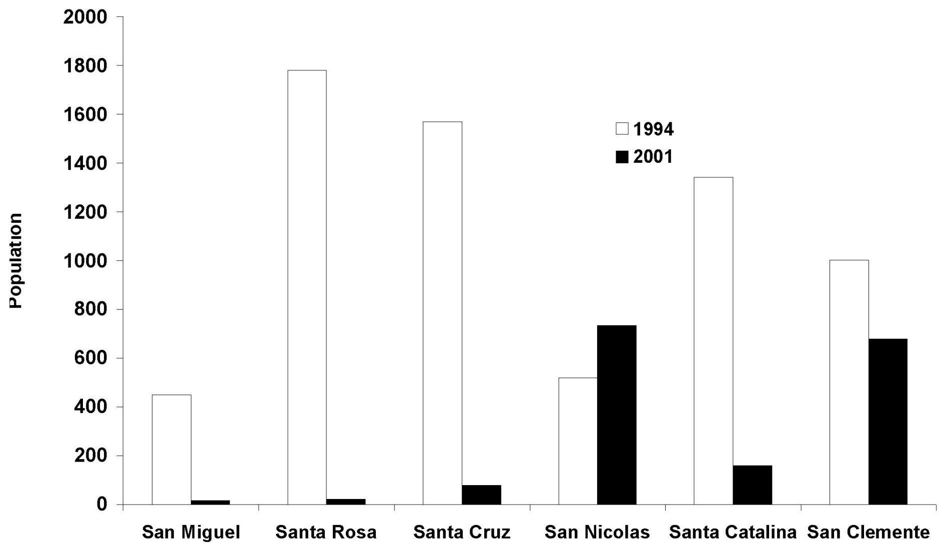

Figure 21.1. Island fox population estimates on each island where they occur, 1994 and 2001. Data are from Roemer et al. (1994) and Coonan (2001).

Island fox recovery actions

Faced with the imminent extinction of three island fox subspecies, NPS convened an ad hoc recovery team in 1999 to assess the status on the northern Channel Islands and to recommend emergency recovery actions. The team, comprising experts in canid conservation, endangered species management, and raptor research and management, concluded that island foxes were rapidly declining toward extinction on the northern Channel Islands, and that golden eagle predation had been confirmed as the primary mortality factor. The team recommended that island foxes be brought into captivity on San Miguel and Santa Rosa Islands to protect them, and to form the basis for a captive-breeding program that would ultimately return island fox populations to viable levels. The team recommended that golden eagles be removed from the northern Channel Islands until the root causes of their presence were rectified; that is, until feral pigs were eliminated from Santa Cruz Island.

Channel Islands National Park began emergency recovery actions in 1999, with the objectives being to remove the primary mortality factor now affecting island foxes (golden eagle predation), and to recover island fox populations to viable levels through captive breeding. Eagle relocation commenced in the summer of 1999 when raptor biologists from the Santa Cruz Predatory Bird Research Group, working under a cooperative agreement with the park, began removing golden eagles from the northern islands by trapping the birds and releasing them in northern California (Figure 21.2). Bow-net traps were set around dead (feral pig) or live (rabbit) bait, and were tripped remotely when eagles alighted on the prey. Between November 1999 and March 20001, 14 eagles were removed from Santa Cruz Island. Several of these were members of pairs that began defending territories in the spring of 2000 but had not nested, most likely due to low numbers of piglets. Satellite telemetry shows that none of the relocated eagles have attempted to return to the islands; most have not attempted to cross the Sierra Nevada. At least seven eagles remained on the island as of spring 2001. Six of these comprised three breeding pairs, either at the incubation or hatchling stages by April 2001. Removal efforts were slated to resume in May 2001, but the island will continue to attract golden eagles until feral pigs are removed.

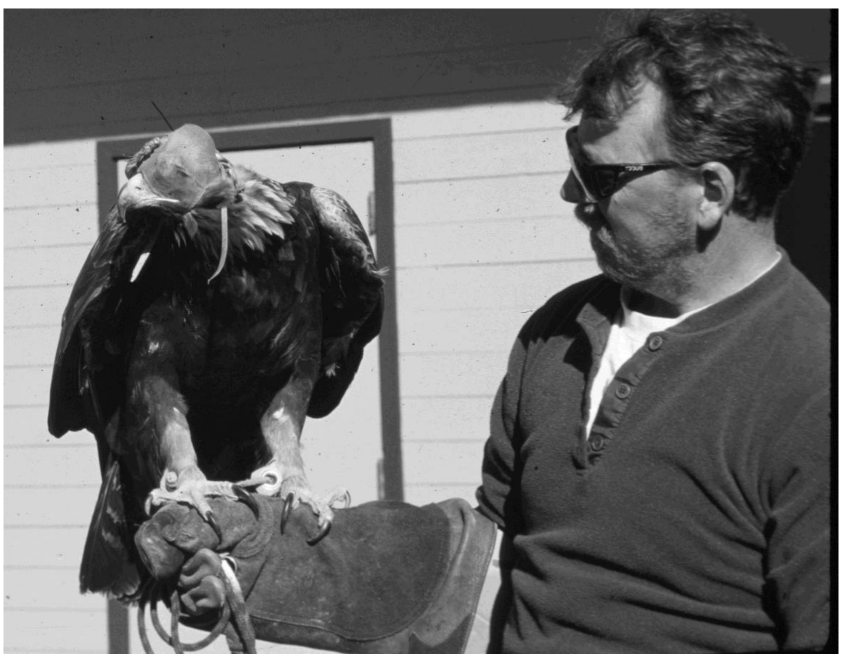

Figure 21.2. Golden eagle captured from Santa Cruz Island for relocation to northeastern California.

In 1999, NPS established an island fox captive-breeding facility on San Miguel Island, and added one on Santa Rosa in 2000 (Coonan and Rutz 2001). The program is being conducted under the guidance of a captive-breeding working group of the island fox recovery team. Fourteen foxes were brought into captivity on San Miguel in 1999 (Figure 21.3), and only one is known to exist in the wild. Of those 14, only four were males, and they were paired with females for the 1999-2000 breeding season. Only one of those pairs produced a litter (of two pups). Three litters were born on Santa Rosa in spring 2000, to females that had conceived in the wild. There are currently 21 foxes in captivity on Santa Rosa, and only one is known to exist in the wild.

Figure 21.3. Island fox pup, Santa Rosa Island captive-breeding facility, May 2001.

Physical establishment of the captive-breeding facilities was logistically challenging, due to the difficulties inherent in transporting materials and labor to the islands. On San Miguel Island, materials were taken by barge to the island and then lifted by helicopter onto the island. Pen construction was primarily by volunteer crews. Despite the difficulties in establishing and maintaining island captive facilities, the alternative of breeding on the mainland is not currently feasible or acceptable. First, there is very little small-canid space available in North American zoos. Second, island foxes are extremely vulnerable to canid diseases and parasites, and any foxes bred on the mainland would potentially vector pathogens to wild populations.

The captive pens (Figure 21.4) are constructed of 6x10-ft chain-link fence panels, about 45 sq m in extent, roofed to prevent foxes from climbing out and to protect them from aerial predators. Each pen has several den boxes and other structures to provide foxes with locations for parturition and privacy.

Island foxes have never been bred in captivity before. Husbandry methods have not been established, and little is known of their reproductive biology. The park, therefore, consulted with numerous canid experts prior to designing pens and developing a standard diet. The park is also cooperating with canid pathologists and reproductive specialists to establish baseline conditions for the species.

The captive foxes' diet comprises high-quality dry dog food supplemented with hard-boiled eggs, vegetables and fruits, and dead coturnix quail and live deer mice *(Peromyscus maniculatus).* Foxes are given semiannual veterinary examinations. Several on-island field surgeries have been conducted to treat ailments, and have necessitated building a separate fox quarantine facility on Santa Rosa Island. In the spring of 2001, an adult female in the Santa Rosa facility died of cancer despite two field surgeries. With the known population of the San Miguel and Santa Rosa subspecies numbering 17 and 22 foxes, respectively, this underscores the importance of each individual in the captive-breeding facilities, and the high level of care required to ensure the ultimate success of the program.

Figure 21.4. Island fox captive-breeding facility, Santa Rosa Island.

As if it were listed

Although there is a low probability that the island fox will be federally listed, the park has nevertheless decided to approach management of the species as if it were listed as endangered. The severity of the recent decline and the profound continuing threats to the species warrant an endangered species-type approach. Were the park not to treat the species with the attention and resources normally reserved for listed species, the potential extinction of three subspecies would contravene all NPS policies regarding conservation of natural resources in general and wildlife and rare species in particular (NPS 2001).

Several aspects of the island fox management program are typical of programs for listed species. First, the primary management measures, golden eagle removal and captive breeding of island foxes, are aggressive, difficult to implement, and largely unprecedented. The scope of recovery actions range from short-term actions, such as eagle removal, to longer-term actions, such as captive breeding of island foxes and eradication of feral pigs from Santa Cruz Island. The cost of recovery is significant; island fox recovery is estimated to take at least 10 years to compete (Coonan 2001), and costs to NPS are estimated at about $5 million. This does not include the costs of pig eradication, which will require $6-8 million.

The park has modeled its approach to island fox management on the U.S. Fish and Wildlife Service (USFWS) model, which includes establishment of a recovery team and development of a recovery plan. The park recognized early on that effecting the recovery of island foxes exceeds NPS capabilities, and requires a broad base of expertise. For example, with captive breeding the park is embarking on a long-term program for which the agency has little proficiency. Thus the island fox recovery team originally convened by the park in 1999 will continue to meet on an annual basis to evaluate the recovery program and provide technical guidance.

The park developed a USFWS-style recovery plan that will serve as a road map to recovery (Coonan 2001). The plan is in the format of a typical USFWS recovery plan, which includes description of the species, the current status and trends, threats to the species, recovery goals and criteria, recovery actions, implementation schedule, and cost estimates. The plan also contains two sections (guidelines for management and need for the action) that are more typical of NPS plans. These were added because although their contents are assumed for USFWS recovery plans, they are critical elements of NPS plans and are needed to establish the necessity for the action and its basis in policy, legislation, and regulation.

The island fox recovery plan contains specific, measurable recovery criteria that are similar to delisting or downlisting criteria used by USFWS. Team members suggested that such criteria be developed using demographic modeling, to ensure that recovery criteria are attainable and have a basis in reality. Accordingly, the demographic modeling program VORTEX was used with island fox population data from San Miguel, Santa Cruz, and San Clemente Islands to determine values of demographic parameters such as adult and juvenile survivorship and female fecundity that would produce stable or increasing populations (Roemer et al. 2000). Modeling was then used to evaluate initial island fox population sizes that would result in robust populations that persist over time, both with and without catastrophic mortality factors such as canine disease and eagle predation. Finally, modeling was used to determine the scope of a captive-breeding program that would return wild populations to targeted levels within a reasonable time.

Obstacles to recovery

The non-listed status of the island fox, coupled with lack of long-term funding sources, present severe problems for recovery efforts. The decade-long recovery program outlined in the plan is largely unfunded, because there is no NPS funding source available for long-term, large-scale resource management actions. Moreover, project proposals for non-listed species do not rank as highly in existing NPS funding programs as those involving listed species. However, if the island fox were listed, it would be eligible for USFWS funding under the federal Endangered Species Act. Moreover, it would have much higher name recognition among the public, which would facilitate outside fundraising. Few people have heard of the island fox, much less realize that it is imperiled.

Listing would also bring the full weight of the Endangered Species Act to bear on the recovery program. If the species were listed, development of a recovery plan would occur under USFWS authority and expertise, but attempting to duplicate the USFWS recovery process within NPS is difficult. Park management is currently uncomfortable with the concept of an ad hoc recovery team, and has suggested that its use violates the Federal Advisory Committee Act. However, threats to biodiversity in the National Park System are unlikely to be abated any time soon, and NPS may find itself increasingly in the unenviable position of viewing non-listed species as functionally endangered. Ecological crises will continue to occur more rapidly than bureaucratic wheels can turn. NPS thus needs to become more comfortable with management actions borne of necessity, or else develop effective Servicewide tools and funding mechanisms to deal with rapid ecological crises.

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22 Ecological restoration in a giant sequoia grove

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Background

The Giant Forest sequoia grove in Sequoia and Kings Canyon national parks, California, is one of the largest and most accessible of the 75 groves. It contains several of the largest trees in the world and is experienced by over 1.5 million visitors each year. To serve visitors, a small city was built in the grove in the early 20th century. Recreational use began in 1903 with the completion of a road connecting the Sierra foothills with Giant Forest, which is at an elevation of 6,500 ft. Visitation to the grove increased dramatically over the next three decades, necessitating the development of an infrastructure that, by 1930, amounted to four campgrounds, numerous parking lots, water and sewage systems, a gas station, corrals, restaurants, offices, retail sales outlets, and over 200 cabin and tent-top lodging structures (Dilsaver and Tweed 1990). These crowded conditions began to impair the scenery and serenity of Giant Forest and to damage the giant sequoia ecosystem. By 1930, park managers began to call for removal and relocation of visitor facilities. In 1997, the removal of facilities from Giant Forest began.

The primary impacts to the forest after a century of human development include the following: modification of landforms; topsoil erosion, loss of organic matter, and compaction; absence of surface litter and duff layer; thinning of and distinct openings in forest overstory; absence or low density of forest understory, including grasses, forbs, shrubs, and tree seedlings; and probable absence or depletion of the soil seed bank (Hartesveldt 1965; Demetry 1997).

Restoration objectives and procedures

Demolition of facilities. The first objective was to demolish and remove infrastructure without causing further damage. To date, 282 buildings, 24 acres of asphalt, dozens of manholes, and all exposed sewer and water pipe, underground propane tanks, and aerial utility lines have been removed. Demolition will be complete in 2002. The extent of demolition accomplished through 2000 is shown in Figure 22.1.

Demolition was accomplished by contractors using either heavy equipment or, in sensitive areas, smaller equipment or hand tools. To protect soils and vegetation, contractors were required to install fencing around sensitive sites and residual vegetation. Travel routes were designated on contract drawings to constrain equipment travel and minimize soil compaction. The most effective mechanism for resource protection was a contract provision that assessed monetary damages for causing injury to trees, soils, or vegetation. Daily oversight of operations was provided by a park restoration ecologist.

To protect shallow roots, underground pipes were left in place unless portions were exposed during demolition. In such cases they were removed to 2 ft below the surface and plugged with concrete to prevent channeling of groundwater through the pipes. Manholes were removed completely, if possible. If more damage would occur by removal, the concrete was demolished to 2 ft below the surface, and the remaining

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concrete fractured prior to backfilling to allow water to drain through. Utility attachments to live trees were removed where it could be done without further damage to the tree. Where removal might cause injury, protruding parts were cut flush with the tree and the bracket left in place.

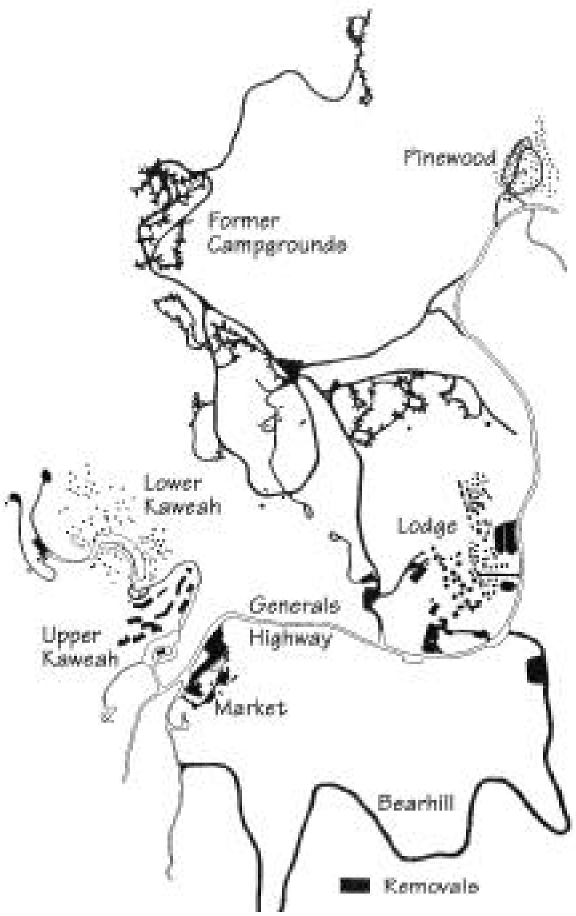

Figure 22.1. Development removed from Giant Forest through 2000 (except Bearhill).

Landform and soils. Objectives for restoring landforms and soils were the following:

1. Re-establish natural contours and drainage patterns by rebalancing cuts and fills with existing soils;
2. Where extant soil is insufficient to restore the landform to a condition that mitigates drainage problems, use other fill in deep layers only, reserving local soil for topdressing; and

3. Restore soil properties to approximate those of surrounding, undisturbed soils. Soil amendments were used with the objective of restoring soil properties rather than accelerating plant growth.

The most severely impacted soil properties were compaction, alteration of aggregate structures, and loss of topsoil organic matter (Demetry 1997). To decompact soils and convert platy and blocky aggregate structures to natural crumb or granular structures, moist soils were cultivated to a depth of 5 to 8 inches. Cultivation was conducted outside the driplines of mature trees and was halted or made shallower if major roots were encountered. To mitigate loss of organic matter in the topsoil, highly decomposed forest bark humus was added to the soil during cultivation in some locations. Contractors conducted soil tests to determine application depth of humus necessary to raise organic matter content to 7-10% by weight. If soil tests indicated that organic amendment would increase the C:N (carbon-to-nitrogen) ratio outside the range seen in reference sites (approximately 30:1), nitrogen fertilizer as slow-release urea or ammonium sulfate was added during cultivation.

Loosened soils were protected with wood chip mulch, soil retention blankets, or native litter and duff, which was salvaged prior to demolition if present or was collected from surrounding areas for restoration of linear features such as roads and trails.

Vegetation. The short-term goal of vegetation restoration in Giant Forest Village is to reproduce the species composition, species density, and spatial pattern of regeneration that would result from a natural fire. The long-term goal is to integrate the site into the natural fire regime typical of surrounding areas of Giant Forest. By ensuring a vegetation structure similar to surrounding sites after one fire, the park maximizes the success of this integration.

This goal uses a natural-disturbance model to define a reference condition for ecological restoration. The model was identified by looking to the surrounding ecosystem for a natural-disturbance condition which resembles the human disturbance that has taken place. In Giant Forest Village, the forest consists of a matrix of mature canopy interspersed with openings, or gaps, where patches of trees were cleared for buildings and parking lots. This condition is similar to areas in undeveloped portions of Giant Forest where prescribed fire has killed patches of mature trees, creating gaps colonized by even-aged patches of shrub and tree regeneration, particularly giant sequoia. Most regeneration following fire occurs as a pulsed, even-aged cohort within gaps, with little regeneration beneath intact canopy. This provides an analogous condition for a revegetation approach where planting is restricted to gaps and conducted within a short time period with one- to two-year-old stock.

This reference condition was quantified in 1994 by mapping and measuring woody vegetation in 18 fire-caused gaps, 7 to 15 years following fire. Gap size was found to account for a significant amount of variability in density, growth rate, and cover of pioneer-type tree and shrub species. More detail is available in Demetry and Duriscoe (1996) and Demetry (1998). Grasses and forbs were found to be a minor component of the vegetation and were not mapped.

Adaptive management. Because of the duration and severity of impacts to developed areas, the park believed that some degree of human intervention was necessary for the recovery of the site. Evidence for this view lies in some formerly developed areas within the grove that were abandoned over 30 years ago and show little natural recovery. However, it was also hypothesized that an acceptable restoration of vegetation might be achieved through less intensive and intrusive means than the seed collection, propagation, planting, seeding, and irrigation process traditionally practiced in the Park's frontcountry revegetation projects. To address this possibility, an adaptive management approach was proposed. The goal of adaptive management was to apply different degrees of active restoration in an experimental manner to determine the minimal intervention necessary to meet the standard reference condition of natural vegetation in fire-caused gaps. Because restoration goals had been quantified, a solid reference condition existed for comparison and evaluation of treatments, making the project an especially good candidate for adaptive management. Experimental treatments were to be applied in early phases of the project and the newly acquired knowledge applied to later phases. Experiments would be carried out at the scale of the gap to best integrate experimentation with management goals.

Three levels of vegetation restoration in Giant Forest Village are being tested, in order of increasing human intervention:

1. *Restore soil only.* In this option, actions are limited to regrading, amending soils in highly disturbed sites, cultivating, and mulching with litter and duff or wood chips. This is considered the minimal treatment. It was used in four experimental gaps in highly disturbed sites, and also in non-gap areas, former campgrounds abandoned for 30 years or more, and in narrow linear road corridor and trail disturbances through established forest.
2. *Restore soil and then burn.* In addition to actions from treatment (1), in this option a light fire fuel bed and several large slash piles were imported and burned with the intent of releasing sequoia seed and scarifying the seed bank. Treatment (2) was used in four experimental gaps in highly disturbed sites.
3. *Restore soil and then plant.* In addition to actions from treatment (1), in this option active planting occurred. Trees, shrubs, grasses, and forbs were propagated from local stock and planted in gaps using prescriptions formed from fire-caused reference gaps (Demetry 1998). Gaps are irrigated for 2 to 3 years to enhance survival. Trees (4 species) were planted as 1- or 2-year bare-root or 1-gal containerized stock, shrubs (12 species) were planted as 10 cu-in leach tube or 1-gal containerized stock, and grasses and forbs (9 species) were seeded or planted as plugs. Treatment (3) was used in the majority of gaps in highly disturbed sites, as it was considered to have the highest probability of success.

The original experimental design for the adaptive management trials called for seven replicates of the three treatments within blocks of gaps of similar size, location, and site conditions, all to be restored in the same year. However, this design was altered in response to funding limitations, contracting constraints, changes in project scope and phasing, and the desire of management to keep the “restore soil” treatment restricted to lower-visibility sites. The number of replicates was reduced to four, resulting in lower statistical power to detect differences when they truly exist. “Plant” and “burn” treatments were applied in 1998 and 1999 in the Lodge site, and the “restore soil” treatment was applied in 2000 in former campground sites (Figure 21.1), resulting in the confounding of treatment effects with year and site effects. It is therefore not possible to attribute causation to treatment alone. However, because it is the goal that any treatment–site–year combination should meet the standard reference condition of vegetation in fire-caused gaps, we believe useful information will still be obtained.

Experimental design and monitoring

Adaptive management trials were conducted to compare vegetation resulting from the three restoration treatments described above and to compare soil properties resulting from the soil amendment treatment with control, pre-restoration, and reference soils.

Restoration treatments were applied in a randomized complete block experimental design with gap size as the blocking factor; there were 4 replicates for each of 3 treatments for a total sample size of 12. Demetry and Duriscoe (1996) found that gap size is a significant source of the variability shown by species densities and heights within gaps; this variability can be accounted for by blocking on gap size. Gaps within size-blocks were randomly selected and assigned to treatments.

To obtain early feedback on treatments, vegetation within the four gaps in each restoration treatment was sampled one growing season after treatment. Grass, forb, shrub, and tree density and cover were sampled within randomly located 1x1-m quadrats, with one quadrat for every 100 sq m of gap area. Number of quadrats per gap ranged from 7 to 40. Data from the quadrats were summed and averaged to arrive at the mean grass, forb, shrub, and tree density and cover for each gap. "Restore soil" gaps were treated in summer 2000, so results for one growing season will not be available until after 2001. Results reported here are for the 8 gaps in the "burn" and "plant" treatments, which were treated in 1998 and 1999.

The soil amendment treatment was applied in a split-plot experimental design in three Lodge gaps receiving the "plant" treatment. In half of each gap, a 0.5-in layer of forest bark humus was spread over the soil surface and mixed in to a depth of 5 in during the cultivation process. Slow release urea (38-0-0) was added at a rate of 20 lbs per 1,000 sq ft to rebalance the C:N ratio to approximately 35:1. The other gap-half was cultivated to a depth of 5 in as a control. In October one year after treatment, samples from the A1 horizon were collected from three locations in each gap-half, mixed, and analyzed for total organic matter. Surface compaction was measured with a soil penetrometer at 20 locations per gap-half in a grid pattern. Soils in amended and control halves of gaps were compared with samples taken in 1996 from the A1 horizon of the same Lodge sites prior to demolition and from natural reference sites.

The Wilcoxon test was used (Siegel 1956; Snedecor and Cochran 1989) as the non-parametric analogue of the paired-samples t-test to detect significant differences between "burn" and "plant" treatment gap vegetation and among reference, pre-restoration, not amended, and amended soils. The probability of type I error was controlled at $\alpha = 0.10$.

In addition to sampling vegetation in quadrats, all planted trees and shrubs in a random sample of "plant" treatment gaps were tagged and measured to provide survivorship and growth data.

Results and discussion of restoration treatments

Grass density was significantly higher in planted gaps than in burned gaps (Figure 22.2, top). No significant differences were detected between forb, shrub, and tree density in planted gaps and burned gaps. Both planted and burned gaps had higher shrub and tree densities than did reference gaps (statistical comparison with reference gaps won't be made until 5 years after treatment), suggesting that both treatments may be successful in achieving woody plant densities typical of fire-caused gaps.

Comparison of plant cover and tree height in planted and burned gaps shows that planting has accelerated vegetative recovery, with significantly greater grass, shrub, and tree cover in planted gaps than in burned gaps (Figure 22.2, bottom). Mean tree height in planted gaps (22 cm) was greater than that in burned gaps (approximately 3 cm), and is approaching mean tree heights in reference gaps (37 cm). Photos taken before and after treatment show woody vegetation visible in planted gaps and not yet visible in burned gaps (Figure 22.3).

Surface compaction in cultivated/amended soils was significantly lower that that in cultivated/not amended and pre-restoration soils, but was still 3.3 times higher than that in reference site soils (Figure 22.4, top). Percent organic matter in cultivated/amended soils was significantly higher than that in cultivated/not amended soils and pre-restoration soils, and no significant difference was detected between organic matter content in amended soils and reference sites (Figure 22.4, bottom).

For soils in a later phase (Upper and Lower Kaweah sites) in which organic matter contents were raised to a mean of 6.4% compared with the mean of 5.9% in the Lodge sites shown here, 1-year soil compaction was only 2.7 times greater than that at reference sites. Data not shown here indicate that loose soils immediately following cultivation become more compact during the following year. The organic amendment may help to maintain soil porosity and keep soils from re-compacting to pre-restoration levels.

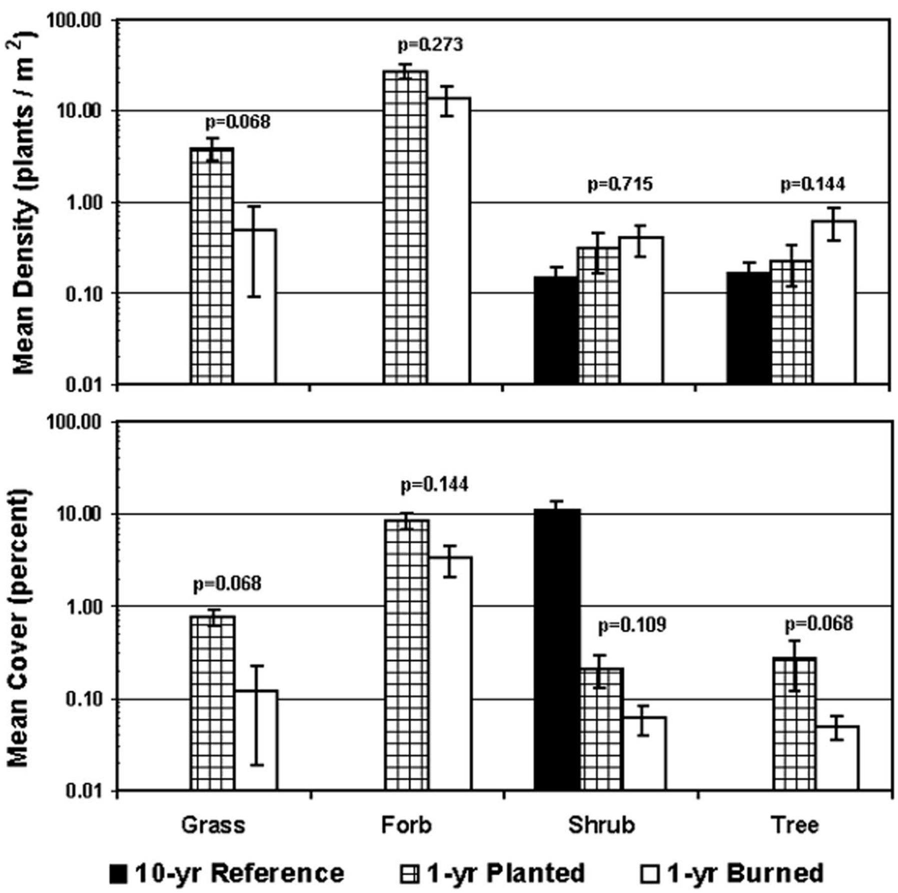

Figure 22.2. Mean density (top) and mean cover (bottom) of grasses, forbs, shrubs, and trees in fire-caused reference gaps approximately ten years after fire (woody species only), and planted and burned gaps one growing season after treatment. For 10-year reference gaps, tree success was also measured as tree height for which mean in reference gaps = 37 cm, mean in 1-year planted = 22 cm, mean in 1-year burned = approximately 3 cm. Error bars show ± one standard error of the mean. P-values shown are results of Wilcoxon tests for paired comparison of planted and burned gaps (see text).

First-year survival of planted trees in the Lodge and Upper and Lower Kaweah sites ranged from 79% for white fir to 100% for incense cedar. First-year survival of planted shrubs ranged from 48% for whitethorn to 100% for mountain dogwood, bitter cherry, and Sierra gooseberry (Table 22.1).

Long-term success of restoration treatments and comparison with reference conditions will continue to be monitored and evaluated at 2, 3, 5, and 10 years after treatment. We expect that the planting treatment might accelerate recovery such that vegetation in planted gaps 5 years after treatment is similar to vegetation in fire-caused gaps 10 years after fire.

Figure 22.3. Top left: Lodge amphitheater site before restoration. Bottom left: Lodge amphitheater site one year after planting treatment. Top right: Lodge cabin site before restoration. Bottom right: Lodge cabin site one year after burn treatment.

In retrospect, it is recommended that unless there is direct control by resource managers over implementation of experimental treatments on similar projects, a better approach to determining the outcomes of different restoration strategies would be to conduct controllable experiments at a smaller scale well in advance of an actual large-scale restoration. However, when constraints are imposed such that pilot experiments are not possible, careful documentation, monitoring, and analysis of restoration treatments applied during project implementation still allow us to learn about the success of those treatments.

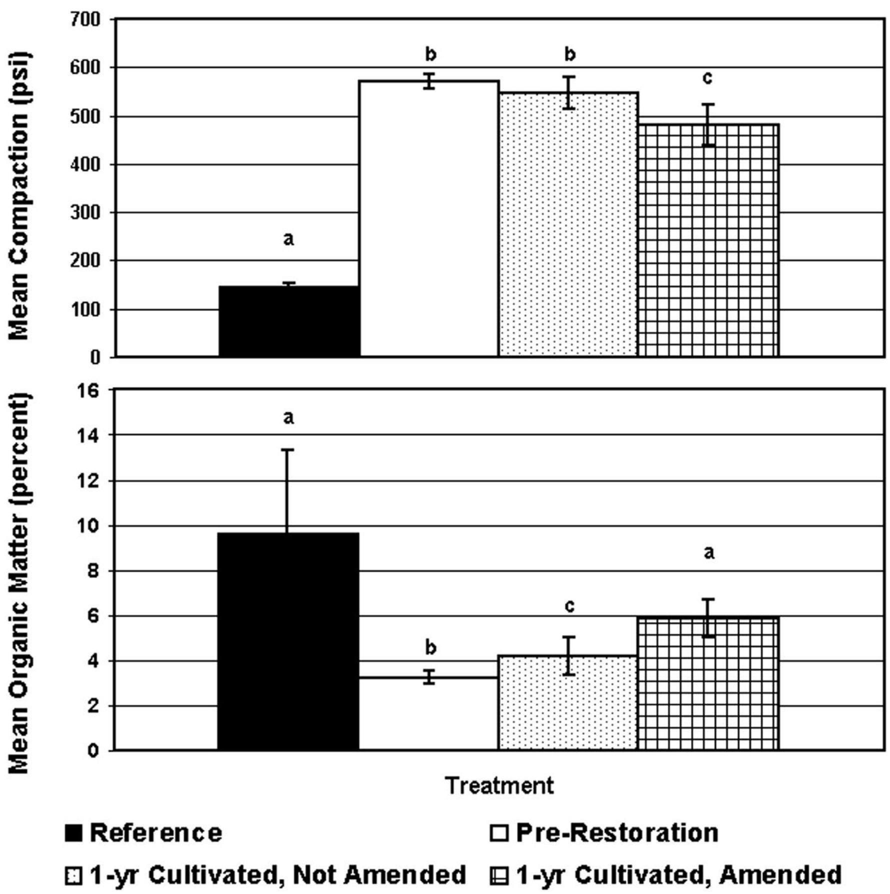

Figure 22.4. Mean surface soil compaction (top) and mean organic matter (bottom) in fire-caused reference gaps approximately ten years after fire, restoration gaps prior to restoration, cultivated but non-amended halves of restoration gaps one year after restoration, and cultivated and amended halves of restoration gaps one year after restoration. Error bars show ± one standard error of the mean. Significant differences resulting from Wilcoxon test for paired comparison of treatments are indicated by different letters (see text).

Name	*Type of stock*	*Number planted*	*Survival rate, 1-year*	*Mean annual growth, Year 1*
white fir *Abies concolor*	bare-root	199	0.79	1.6
incense cedar *Calocedrus decurrens*	bare-root	91	0.91	2.7
	1-gal	9	1.00	1.6
sugar pine *Pinus lambertiana*	1-gal	59	0.83	2.3
giant sequoia *Sequoiadendron giganteum*	bare-root	2,684	0.90	1.3
	1-gal	419	0.90	1.6
greenleaf manzanita *Arctostaphylos patula*	leach tube	108	0.82	10
	1-gal	121	0.93	-97
whitethorn *Ceanothus cordulatus*	leach tube	617	0.48	61
	1-gal	98	0.52	-68
littleleaf ceanothus *Ceanothus parvifolius*	leach tube	30	0.70	254
chinquapin *Chrysolepis sempervirens*	1-gal	7	0.57	-210
mountain dogwood *Cornus nuttallii*	leach tube	16	1.00	50
	1-gal	5	1.00	-37
bitter cherry *Prunus emarginata*	leach tube	11	1.00	-2
Sierra currant *Ribes nevadense*	leach tube	59	0.86	26
	1-gal	28	0.96	-309
Sierra gooseberry *Ribes roezlii*	leach tube	42	1.00	192
	1-gal	30	0.97	1,360
western raspberry *Rubus leucodermis*	leach tube	40	0.83	413
creeping snowberry *Symphoricarpos rotundifolius var. parishii*	leach tube	83	0.76	138

Table 22.1. Survival rate and mean annual growth of planted stock after one growing season for stock planted through spring 2000 in 16 monitoring gaps in Lodge and Upper and Lower Kaweah. Leach tube stock is 10-cu-in leach tubes; 1-gal stock is 4-in-sq tree pots. Mean annual growth is expressed in cm (for tree height) or sq cm (for shrub cover).

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23 Meeting resource management objectives with prescribed fire

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Introduction

The events of the 2000 fire season caught the interest of the media, the public, and many politicians. The destruction of homes in the wildland–urban interface was an obvious negative result of some of these fires. In addition, some fires burned with uncharacteristically high intensity, causing resource damage that may take a long time to recover. While the media tended to focus on these negative, destructive effects of fire, many of the fires of 2000 were beneficial, restoring a natural process often long absent in fire-maintained ecosystems. While attention was brought to the National Park Service (NPS) and prescribed fire, NPS prescribed-fire program accomplishments were omitted from ensuing discussions. We present examples from three parks where prescribed fire is successfully used to meet fire and resource management objectives: Sequoia and Kings Canyon National Parks, Grand Canyon National Park, and Bandelier National Monument.

Results from these park examples were obtained using established protocols from the NPS fire monitoring program (National Park Service 2001). The program's objectives are to: (1) record basic information for all fires; (2) document fire behavior; (3) determine whether prescribed-fire management objectives are achieved; (4) document and analyze short-term and long-term fire effects on vegetation; (5) establish recommended standards for data collection, analysis, and sharing; (6) follow trends in plant communities where fire effects literature exists; and (7) identify where additional fire effects research is needed. The NPS fire monitoring program utilizes permanent plots to measure a variety of vegetation and fuels attributes pre-burn and post-burn. This program began in some western parks in the 1980s and has expanded over the last decade to include all NPS units that use prescribed fire. This monitoring scheme is now implemented in over 50 parks nationwide and has also been adopted by other federal and private agencies.

First things first: setting fire and resource objectives

When implementing such a monitoring program, having benchmarks to serve as reference points for program success is critical. The best available information is used to formulate realistic objectives for resource conditions in order to make progress towards achieving goals. This information may include research data, field sample data, written historical accounts, and historic photographs. In some cases, interpreting what little information is available is very challenging; however, resource managers must make decisions even in the face of uncertainty. Once a target condition is agreed upon, specific objectives are written, a desired degree of certainty in the results is determined, and protocols are established to collect the appropriate

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data. Involving the park staff at many levels, as well as local scientists from universities or cooperating–neighboring agencies, is vitally important to this process. It is also essential for all staff to remember that setting objectives is a work in progress and when new information is available, or unexpected trends are identified, objectives may need to be revised or the program re-evaluated. When new information is used to re-evaluate program goals or objectives, the adaptive management process comes full circle.

Prescribed fire success stories

Example 1—Sequoia and Kings Canyon national parks: Giant sequoia–mixed conifer forest type. Sequoia and Kings Canyon national parks are located in central California in the southern Sierra Nevada range. The parks' prescribed fire program began in 1969 after nearly a decade of fire research in giant sequoia groves, and the parks' fire effects monitoring program began in 1982. The giant sequoia–mixed conifer forest, where prescribed fire efforts were first focused, is located at elevations ranging from 5,500-7,200 ft on all aspects with coarse and acidic soils. The overstory consists of mature white fir *(Abies concolor),* sugar pine *(Pinus lambertiana),* giant sequoia *(Sequoiadendron giganteum),* incense cedar *(Calocedrus decurrens),* and ponderosa pine *(Pinus ponderosa).*

The goal in this forest type is to reduce fire hazard and restore and maintain the natural fire regime, first restoring forest structure within a range of conditions present in the 1,000 years prior to settlement. Fuel reduction and stand density target conditions were defined using a combination of research data and expert opinion in a collaborative effort involving park staff and local U.S. Geological Survey Biological Resources Division scientists. Two specific objectives are measured to ensure that restoration target conditions are reached: (1) reduce total fuel load by 60-80% immediately after the initial prescribed fire; and (2) reduce stand density to 50-250 trees/ha (for trees <80 cm in diameter at breast height) and 10-75 trees/ha (for trees >80 cm in diameter at breast height) by five years after the initial prescribed fire.

Monitoring results indicate that in 28 plots that were distributed within 17 different fires that burned over a period of 14 years, mean total fuel load was reduced by 77% immediately post-burn (Keifer et al. 2000). The fuel reduction objective is successfully met with the initial prescribed fire treatment in the giant sequoia–mixed conifer forest type.

Prior to burning, the mean density of smaller-diameter trees is over twice the maximum target density (Figure 23.1). By one year post-burn, mean density of this size class is dramatically reduced, although the mean does not fall within the target range. Five years following prescribed fire, density is further reduced and the mean (and nearly the entire 80% confidence interval) falls within the target range. Larger-diameter tree density is only slightly reduced over the five-year time period and none of the post-burn large tree mortality are giant sequoias (Figure 23.1). The forest structure restoration objective is largely met after a single treatment with prescribed fire in this forest type.

Once restoration target conditions are met, the objective shifts to using targets for maintaining the fire regime (e.g., ranges of historic fire return interval, season and severity of fire; Keifer and Manley, in press). Rather than attempting to maintain a fixed forest structure, the fire regime will then influence and shape ecosystem structure and function.

Example 2—Grand Canyon National Park: South Rim ponderosa pine type. Grand Canyon National Park is located in northern Arizona on the Colorado Plateau. The prescribed fire program started in the early 1970s and continues to concentrate on the forested plateaus on the north and south side of the Grand Canyon. The South Rim ponderosa pine forests are dominated by ponderosa pine *(Pinus ponderosa),* but piñon pine *(Pinus edulis),* Utah juniper *(Juniperus osteosperma),* and Gambel oak *(Quercus gambelli)* may also be present. These stands are located at

6,000-7,500 ft in elevation on all aspects with shallow, silty loam soils, and barren rock outcrops.

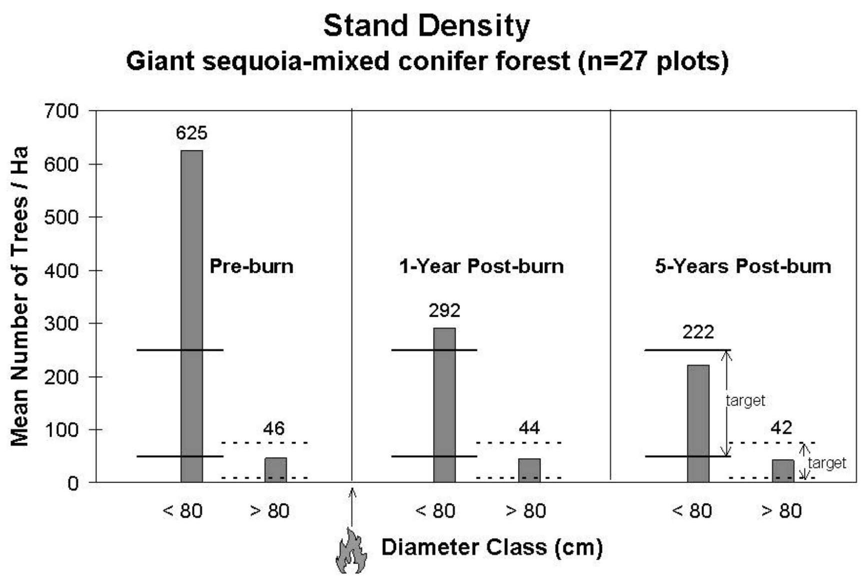

Figure 23.1. Giant sequoia–mixed conifer forest stand density reduction at Sequoia and Kings Canyon national parks. Error bars indicate 80% confidence intervals.

The goal in these old-growth ponderosa pine stands is to use prescribed fire to restore the forest structure present before fire suppression activities. First, fuels must be reduced before a lightning- or human-caused fire burns through them in an uncharacteristically intense manner. Additionally, it is important to minimize overstory ponderosa pine mortality, as there is not an overabundance of trees in the large size classes. Before burning, mean fuel loads are at least twice as high as the maximum historic levels, and caution is needed to keep fires cool enough to limit overstory mortality.

In the South Rim ponderosa pine monitoring type, overstory, and fuel load targets were defined using local research results and written historical accounts. Two objectives are used to measure success in achieving this goal: (1) reduce total fuel load to 0.2-9.3 tons/ac within three prescribed fire cycles, and (2) maintain overstory ponderosa pine densities of 47-62 trees/ha, measured five years after the initial prescribed fire.

Prior to the first-entry prescribed fire, total fuel loads averaged 15 tons/ac. After one prescribed fire treatment, fuel loads are reduced to a level just within the target range of desired conditions (Figure 23.2). Nine plots are needed to assess the fuel load with the desired 80% confidence; however, data have been collected only on seven plots. Although there is not statistical confidence in this trend across all South Rim ponderosa pine stands, it is occurring on seven plots.

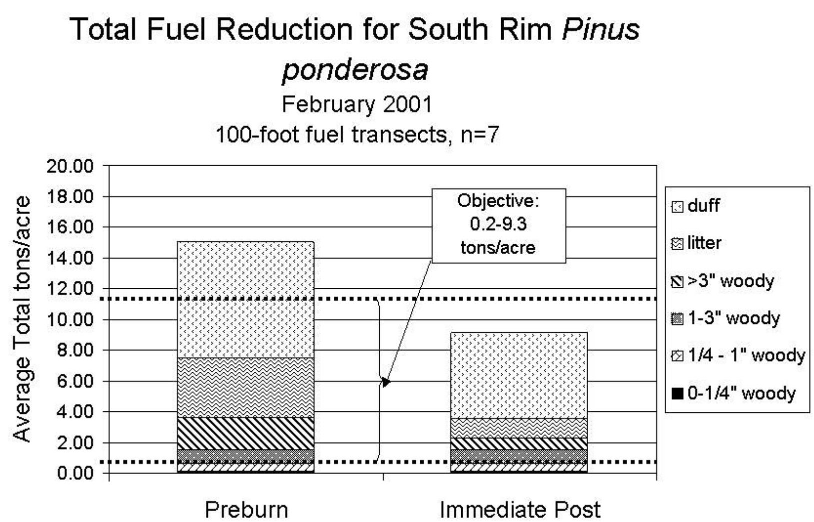

Figure 23.2. South Rim ponderosa pine total fuel reduction at Grand Canyon National Park. Dashed lines represent target condition.

For ponderosa pine trees over 41 cm in diameter, the objective is to achieve and maintain 47-62 trees/ha five years after the burn. Since delayed mortality can still be seen in up to the fifth year post-burn (Harrington 1993), that is when success in meeting this objective will be measured. Because only 11 plots have reached the five-year post-burn visit, two-year post-burn data were analyzed to identify trends. Pre-burn and post-burn overstory densities on 20 plots that have reached the two-year post-burn time period show little change (Figure 23.3).

At Grand Canyon, a good portion of the fuel reduction has been achieved after one prescribed burn, while at the same time there is not significant ponderosa pine overstory mortality. These data illustrate the trend toward simultaneously reducing fuels and limiting overstory ponderosa pine mortality. It is expected, through a series of burns, that fuel loads will continue to be decreased while overstory ponderosa pine structure is retained in these forests, and monitoring will continue to ensure that this is indeed true.

Example 3—Bandelier National Monument: Lower-elevation ponderosa pine type. Bandelier National Monument is located on the southern end of the Pajarito Plateau in the Jemez Mountains of northern New Mexico. This area is composed of volcanic ash and lava flows that have been eroded into deep canyons. Nearly all of the monument's vegetative communities have been significantly affected by historical land-use practices, such as grazing and fire suppression. The consequences of these anthropogenic effects have resulted in dramatic changes in the fire regimes at Bandelier and have produced significant ecological effects on the fire-prone landscapes (Allen 1989).

Research shows that the synergistic effects of extensive overgrazing, effective fire suppression after the 1900s, and climate patterns (including a severe drought that occurred in the Southwest in the 1950s) have produced rapid ecosystem changes in the lower-elevation (5,500-7,000 ft) ponderosa pine vegetation type (Allen 1998). Decreased herbaceous plant cover and productivity, ponderosa pine overstory tree mortality, and increased densities and up-slope recruitment of piñon and juniper trees are a few of the observable effects.

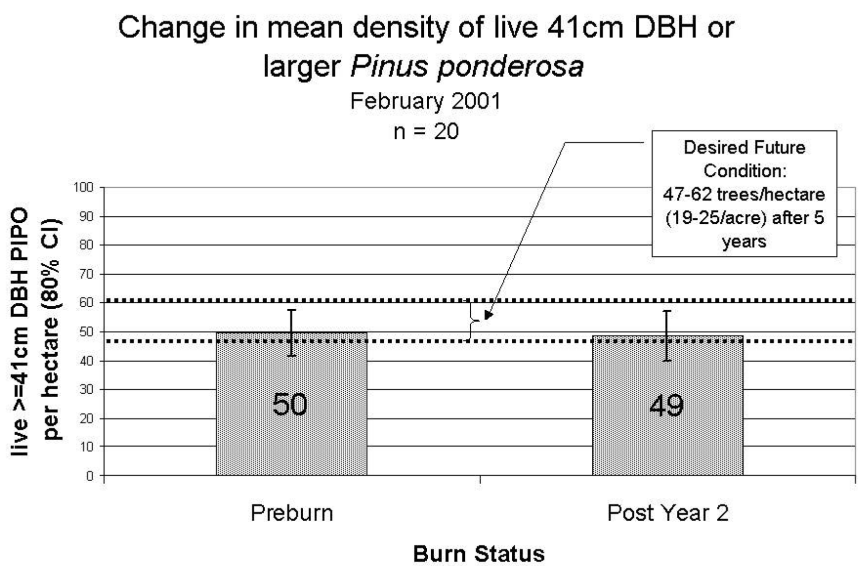

Figure 23.3. South Rim ponderosa pine overstory density changes at Grand Canyon National Park. Error bars indicate 80% confidence intervals.

Fire and resource managers at Bandelier established sustainable management objectives for the lower-elevation ponderosa pine type based upon the park's resource management plan and local ponderosa pine research. The overall goal is to use fire to restore the ponderosa pine forest structure to the natural range of variability present between 1600 and 1880. Specific objectives are: (1) reduce piñon and juniper pole tree density by at least 20% within five years post-burn, and (2) reduce ponderosa pine overstory (diameter at breast height >20 in) tree density by no more than 10% within five years post-burn.

Park managers burned the area in 1992 and again in 1997. Data analysis after two prescribed fire cycles shows a decrease in pole-sized piñon pine and juniper tree densities from pre-burn levels of 16 trees/ac to one tree/ac two years after the second burn (Figure 23.4). Piñon and juniper pole tree densities are now within the target condition (a maximum of 12 trees/ac) for this vegetation type, successfully meeting the primary objective.

The data also show a slight increase in overstory ponderosa pine density from six trees per acre prior to the burn, to approximately 8 trees per acre two years after the second burn (Figure 23.5). This demonstrates that the second objective is also accomplished.

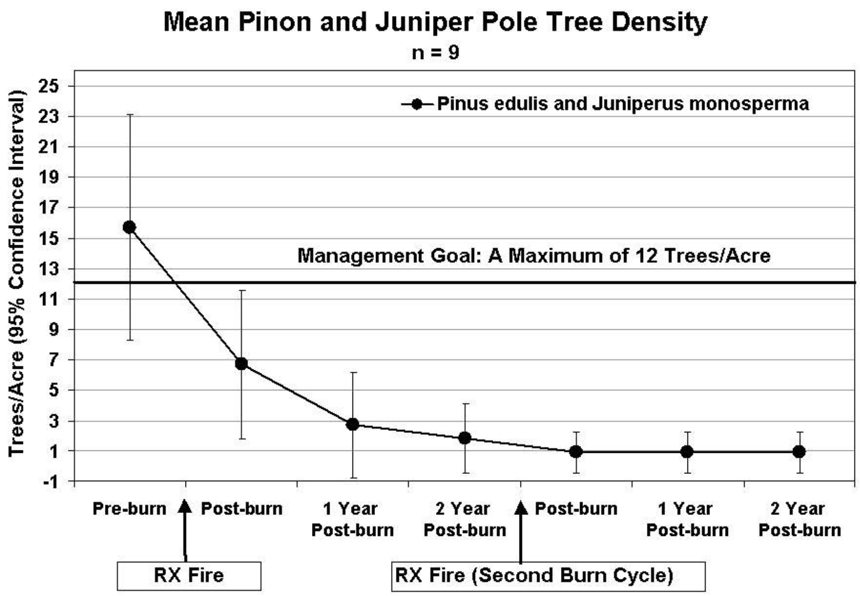

Figure 23.4. Lower-elevation ponderosa pine mean pole tree density at Bandelier National Monument. Error bars represent 95% confidence intervals.

At this time, no alterations need to be made to the burn prescription or treatment frequency because managers at Bandelier are reasonably certain that pole-sized piñon and juniper tree densities have decreased, and overstory ponderosa pine densities have, at a minimum, been maintained. However, monitoring will continue in the lower-elevation ponderosa pine forest to track long-term changes in tree densities and corollary effects, such as increases in exotic species, which may negatively affect ecosystem function.

Conclusions

Examples from three different national parks demonstrate the success of NPS's prescribed fire program. Sequoia and Kings Canyon national parks simultaneously achieve fuel reduction and forest structure restoration objectives in the giant sequoia–mixed conifer forest. Grand Canyon National Park successfully reduces fuels while maintaining overstory ponderosa pine in the South Rim ponderosa pine forest type. In the lower- elevation ponderosa pine forest at Bandelier National Monument, piñon pine and juniper tree densities are reduced, while overstory ponderosa pine tree density is maintained. These three examples illustrate that prescribed fire can be used successfully and safely to achieve fire and resource management objectives.

These examples illustrate that prescribed fire, without mechanical thinning, achieves management goals, at least in some forest types. To achieve success within the social and political arena, we need to advertise fire successes to inform the public and Congress. As land management agencies explore fire hazard mitigation alternatives and evaluate prescribed fire use, we are responsible for understanding, weighing, and explaining all benefits and risks of both using fire as a resource management tool and excluding fire from fire-maintained ecosystems.

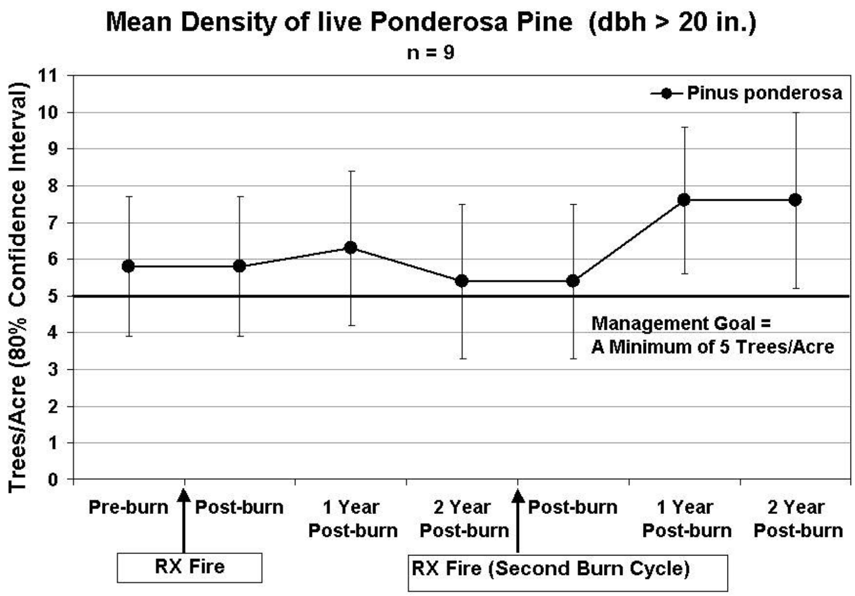

Figure 23.5. Lower-elevation ponderosa pine density at Bandelier National Monument. Error bars represent 80% confidence intervals.

Lastly, landscape-level success is dependent upon the degree of interdisciplinary collaboration between agencies. The fire events of 2000 demonstrate an urgent need for government agencies, private landowners, and the public to work together to reduce the risk of damaging fires and to achieve ecological goals with fire on public lands across vast landscapes.

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24 Reintroduction of bison into the Rocky Mountain parks of Canada: historical and archaeological evidence

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Introduction and Methods

Parks Canada is required by legislative statute to maintain the ecological integrity of Canada's national parks, which includes restoring extirpated species (Parks Canada 2000a-b). To determine if bison *(Bison bison)* were indigenous to the southern Canadian Rockies, we conducted a detailed analysis of first-person historical journals and reviewed existing archaeological data (Kay and White 1995; Kay et al. 1999; Kay, Patton, and White 2000). For, as Aldo Leopold noted over 40 years ago, "if we are serious about restoring [or maintaining] ecosystem health and ecological integrity, then we must know what the land was like to begin with" (Covington and Moore 1994, 45). Five Canadian national parks are found in the Rocky Mountain Cordillera: Banff (Canada's oldest, established in 1885), Yoho (1886), Waterton Lakes (1895), Kootenay (1920), and Jasper (1907). Yoho and Kootenay are located west of the Continental Divide in British Columbia, while Banff, Jasper, and Waterton Lakes are situated east of the divide in Alberta (Figure 24.1).

Some people have used selected quotes from historical journals as evidence that certain animals were or were not abundant during the late 1700s and early 1800s (Byrne 1968; Nelson 1969a; Nelson 1969b; Nelson 1970). With selective quotations, however, there is always a question of whether or not the author included only those passages that support some preconceived hypothesis (Kay 1990; Kay 1995c; Kay and White 1995). To overcome any problems of bias, we systematically recorded all observations of ungulates and other large mammals found in first-person historical accounts of exploration in the southern Canadian Rockies from 1792 to 1872. We then tabulated those data in three ways (Kay et al. 1999; Kay, Patton, and White 2000). First, animals seen; second, game sign encountered or referenced; and third, animals shot or killed. For this analysis, we divided the southern Canadian Rockies into three contiguous geographic regions—the Alberta Foothills, the Rocky Mountains, and the Columbia Valley in British Columbia (Kay et al. 1999; Kay, Patton, and White 2000).

We used only first-person journals penned at the time of the event or edited versions written soon thereafter because later narrative accounts are less accurate (MacLaren 1984; MacLaren 1985; White 1991, 613-632; MacLaren 1994a-c; Shaw and Lee 1997). Even "the humblest narrative is always more than a chronological series of events" (McCullagh 1987, 30). The ideological implications of most narrative historical accounts are "no different from those of the narrative form in fiction" because narratives are always influenced by prevailing cultural myths (Galloway 1991, 454; Pratt 1991; Cronon 1992; Demeritt 1994; Wishart 1997; Kearns 1998). In addition, we used standard techniques developed by historians to gauge the accuracy of all historical journals analyzed during this study (Forman and Russell 1983).

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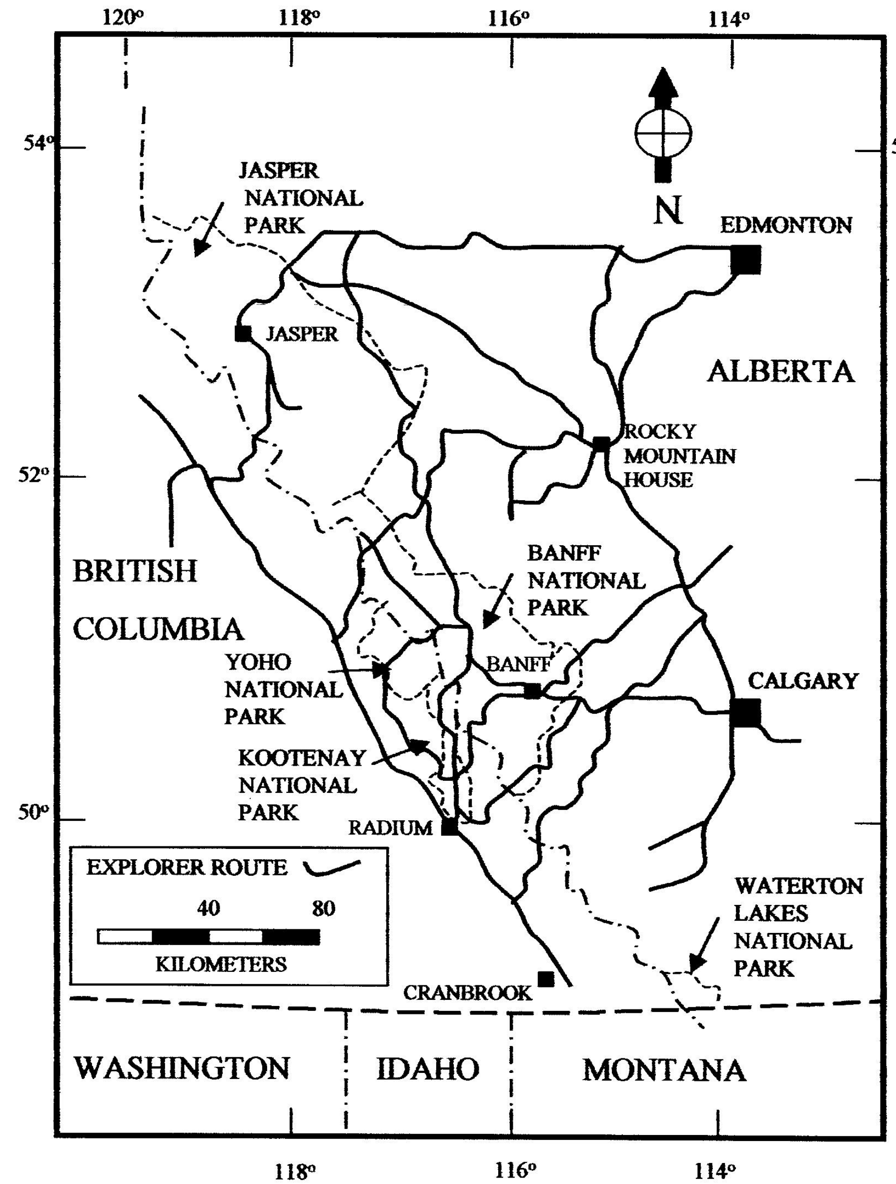

Figure 24.1. Routes of early explorers to the southern Canadian Rockies. Some routes were traveled by more than one expedition. Also shown are Banff, Jasper, Kootenay, Waterton Lakes, and Yoho national parks, as well as present cities and towns.

To determine the relative abundance of ungulate species in pre-Columbian times, we reviewed all available reports for archaeological sites in the southern Canadian Rockies (Kay et al. 1999). This included the Alberta Foothills from the U.S. border north to the Smoky River, the Rocky Mountains from Montana to Jasper National Park, and the entire Rocky Mountain Trench including the middle Kootenay, upper Columbia, and Canoe River valleys. In all, we consulted more than 200 studies. We also conducted an extensive review of the archaeological literature on site formation processes so that we could make informed interpretations from the archaeological record. Taphonomic and transportation questions were given major consideration. Moreover, we reviewed ethnographic material for peoples who inhabited the Canadian Rockies and adjoining prairies at historical contact.

Results

Early explorers visited most parts of the Canadian Rockies, although their travels were generally confined to major river drainages and established mountain passes (Figure 24.1). David Thompson first crossed the Canadian Rockies in 1807 by way of the North Saskatchewan River, Howse Pass, and the Blaeberry River. The Peigan people, however, objected to Thompson trading with their enemies west of the divide and by 1810, the Peigan had closed the North Saskatchewan to Europeans. This forced David Thompson and the North West Company to find an alternative route farther north using the Athabasca River, Whirlpool River, Athabasca Pass, and Wood River to reach the Columbia. The North Saskatchewan route passed through what is now the northern portion of Banff National Park, while the Athabasca Trail traversed today's Jasper National Park (Kay et al. 1999; Kay, Patton, and White 2000).

Only after the Peigan shifted their trade to American posts on the Missouri River, and then lost their warriors to repeated European-introduced epidemics and other colonial processes, did explorers gain access to the southernmost Canadian Rockies (Smith 1984; Kidd 1986). As a result, the first Europeans known to have traveled Banff's Bow Valley did so only in 1841, and the area comprising Banff, Kootenay, and Yoho national parks was not fully explored until Dr. James Hector of the Palliser Expedition arrived in 1858. By then, the fur trade was declining, and the region's mineral-poor rocks failed to attract the onrush of prospectors that occurred further west in British Columbia.

Historically, ungulates were not common in the southern Canadian Rockies or elsewhere in the Intermountain West (Kay 1990; Kay 1994; Kay 1995a-c; Kay 1997a-c; Kay 1998; White et al. 1998). Nevertheless, bison were the second most frequently observed ungulate species in the Canadian Cordillera (Table 24.1). Bison were also the most commonly encountered ungulate in the Alberta Foothills, but early explorers failed to report seeing bison or those animal's sign in the Rocky Mountain Trench (Table 24.1). Between 1807 and 1810, David Thompson reported killing 22 bison on six separate trips up the North Saskatchewan River, primarily on the Kootenay Plains (Kay et al. 2000). Thompson also reported a bison pound (trap) near Howse Pass, as well as chasing a small herd of bison up and over Howse Pass into British Columbia (Kay et al. 1999). Alexander Henry reported bison on the Kootenay Plains and bison sign further west in today's Banff National Park during a winter expedition in 1811. Similarly, David Thompson reported killing bison in the Athabasca Valley just east of the present Jasper National Park, as well as bison sign further west in the park (Kay et al. 1999). Later explorers to the Canadian Rockies, however, seldom saw or killed any bison, though they did report old bison sign, including bison skulls (Kay et al. 1999).

Archaeological evidence indicates that bison and other ungulates were also rare throughout the mountain cordillera in pre-Columbian times (Kay 1990; Kay 1994; Kay 1998; Kay and White 1995; Kay et al. 1999). In fact, for the last 10,000 years, Intermountain aboriginal diets generally contained only a small amount of ungulate foods, often 10% or less (Kay 1994; Kay 1998). Nonetheless, of the ungulate faunal remains recovered from archaeological sites in the southern Canadian Rockies, bison was the most common species in the Alberta Foothills and on the east slope of the Rocky Mountains (Kay et al. 1999; Langemann 2000b). Bison were the most commonly unearthed ungulate in Waterton Lakes National Park, in Crowsnest Pass, and on the lower Bow and Red Deer Rivers. Even in Banff National Park, where human occupation has been dated to 10,300 BP (years before present; Fedje et al. 1995), bison outnumbered other ungulates in archaeological sites. Bison have even been unearthed from archaeological sites in the Rocky Mountain Trench (Langemann 2000b, 7), but it is thought that those bones were deposited by aboriginal people who killed the animals on the east side of the Continental Divide, as there is no evidence that modern bison ever inhabited southern British Columbia (Kay et al. 1999). [Ed. note: an additional table describing these faunal remains could not be included here because of size constraints. See Kay et al. 1999 for details.]

Ecoregion	***Elk***	***Bison***	***Deer***	***Bighorn***	***Moose***	***Mtn. goat***
Alberta Foothills						
Animal sign	1	4	0	0	4	0
Animals seen	19	35	32	4	8	0
Animals killed	19	43	24	5	9	0
Total	39	82	56	9	21	0
Percent	19	40	27	4	10	0
Rank	3	1	2	5	4	6
Rocky Mountains						
Animal sign	11	19	6	12	10	7
Animals seen	12	39	7	69	27	23
Animals killed	9	34	6	113	26	17
Total	32	92	19	194	63	47
Percent	7	21	4	43	14	11
Rank	5	2	6	1	3	4
Rocky Mountain Trench						
Animal sign	5	0	6	0	4	0
Animals seen	7	0	14	2	2	1
Animals killed	7	0	13	3	1	2
Total	19	0	33	5	7	3
Percent	28	0	49	7	10	4
Rank	2	6	1	4	3	5

Alberta Foothills (1792-1863): 29 expeditions, 212 party-days.
Rocky Mountains (1792-1872): 26 expeditions, 369 party-days.
Rocky Mountain Trench (1807-1859): 11 expeditions, 161 party-days.

Table 24.1. Historical evidence relating to the distribution and abundance of ungulates in the southern Canadian Rockies, 1792 to 1872. Animal sign is the number of times animal sign was observed; animals seen is the number of occasions on which various species were seen; animals killed is the number of animals early explorers reported as having killed. Party-days is the total length of time the early exploring parties spent in each ecoregion; expeditions is the number of groups that visited each ecoregion. Species: elk *(Cervus elephus)*, bison *(Bison bison)*, mule deer *(Odocoileus hemionus)* and white-tailed deer *(O. virginianus)*

combined, bighorn sheep *(Ovis canadensis),* moose *(Alces alces),* and mountain goat *(Oreamnos americanus).* After Kay et al. 1999; Kay, Patton, and White 2000.

Bison bone has not been recovered from archaeological sites in Jasper National Park because few sites have been excavated in that area and bone does not preserve well in those acidic soils (Kay et al. 1999; Langemann 2000b). Surprisingly, few bison bones have been recovered from Kootenay Plains on the North Saskatchewan River, but there all the larger known archaeological sites were flooded when Bighorn Dam was constructed (Kay et al. 1999).

Discussion

Although free-ranging bison have been absent from Canada's Rocky Mountains for more than 100 years (Kopjar 1987), historical sources confirm that bison were present in Banff and Jasper national parks during the early 1800s, while archaeological evidence indicates that bison were present for at least 9,000 years. It has been suggested that these were mountain or wood bison *(Bison bison athabascae),* which maintained populations separated from bison *(B. b. bison)* found on the plains (Meagher 1973; Kopjar 1987). The available data, however, does not support this interpretation. First, there is no morphometric evidence that mountain or wood bison is a valid subspecies (McDonald 1981). Geist (1991) reported that wood bison was an ecotype, not a subspecies, a conclusion supported by genetic analyses (Bork et al. 1991). This suggests that whatever bison were in the mountains during pre-Columbian times or historically were not isolated from bison on the Canadian prairies.

Second, unless constantly replenished with animals from the plains, it is unlikely that bison could have maintained viable populations in the mountains (Kay et al. 1999). Long-term studies in Wood Buffalo National Park indicate that wolf *(Canis lupus)* predation alone can have a dramatic impact on bison numbers, keeping the population well below the level the range could otherwise support (Carbyn, Oosenbrug, and Anions 1993; Carbyn, Lynn, and Timoney 1998; Joly and Messier 2000), while studies of hunter–gatherers indicate that native hunters were the ultimate keystone predator that limited the numbers and distribution of all ungulate species, including bison (Kay 1994; Kay 1997c; Kay 1998). This interpretation complements the view that bison once summered on the Canadian prairies but then moved into the foothills and aspen parklands, and we would add montane valleys, to avoid harsh winters on the open plains (Moodie and Ray 1976; Morgan 1980; Hanson 1984; Chisholm et al. 1986; Bamforth 1987; Epp 1988). Some bison may have summered in the mountains, but non-migratory animals would have been under intense predation by Native Americans, wolves, and bears *(Ursus arctos* and *U. americanus).*

Near the head of the Red Deer River in Banff National Park, for instance, there are house pits at the foot of Drummond Glacier that continue to puzzle archeologists (Magne 1994; Langemann 1995; Langemann 2000b). This is a 3,000-year-old stratified site "where the only faunal remains to date are from bison" (Langemann 2000b, 7). Pit houses were very labor-intensive structures to build and are usually associated with Interior Plateau cultures and winter village sites at low elevations in the central Columbia Basin, not the Rocky Mountains (Langemann 1987; Magne 1994; Langemann 1995). We propose that these pit houses were part of a sophisticated management system employed by native people to herd bison into the mountains. This system included extensive aboriginal burning (White 1985; Kay 1995a-b; Heathcott 1999; Kay 2000) to both attract bison and make it easier for people to drive bison to killing sites deep in the mountains (White et al. 2001). This would have lowered those people's transportation costs, as it would have required less energy to transport dried meat and other bison products from kill sites near the Centennial Divide than from areas 50-100 km to the east. In addition, this strategy would have minimized risk associated with people from the interior of British Columbia hunting bison on the Canadian prairies that were claimed by plains tribes, as these two distinct cultural groups were often engaged in open warfare and other hostilities (Smith 1984; Kidd 1996).

To test this hypothesis, Parks Canada subjected archaeologically recovered bison bone to stable carbon analysis (Langemann 2000a-b). Cool-season, or C3, plants fix ^{12}C and ^{13}C isotopes in different proportions than warm-season, or C4, grasses, which, in turn, are incorporated into the bones of herbivores who consume those plants. Thus, by performing isotopic analyses, it is possible to determine the proportion of C3 and C4 plants consumed by bison that once frequented western ranges (Chisholm et al. 1986; Tieszen 1994; Gannes et al. 1997). Moreover, because C4 plants are exceedingly rare in the Alberta Foothills and mountains, if bison unearthed from sites in the Canadian Rockies had a high proportion of C4 plants in their diets, then those animals would necessarily have spent a considerable portion of their lives several hundred kms to the east and south on the Great Plains (Chisholm et al. 1986; Langemann 2000a-b).

Of the bison bones analyzed to date, samples from Waterton Lakes and Banff national parks indicate that those animals consumed a significant proportion of C4 plants. Bison from Waterton Lakes had up to 28% C4 plants in their diet (Langemann 2000a), which is similar to bison tested further east on the Canadian prairies (Chisholm et al. 1986, 201). Even bison from deep inside Banff National Park once consumed major quantities of C4 plants—up to 14% of their diets, which again is significant since there are virtually no C4 plants in the park. Thus, these data support the hypothesis that bison found in the Rocky Mountains commonly migrated to and from the xeric grasslands on the northern Great Plains, a distance of several hundred kms. These data also support the hypothesis that "mountain bison" is not a valid subspecies or ecological concept, and that bison from the plains were a source population for bison that were under intense human and carnivore predation in the more confined mountain and foothill valleys (Kay et al. 1999).

Conclusions

Historical and archaeological data indicate that plains bison once frequented the Alberta Foothills and Canadian Rockies. Archaeological and other evidence suggest that those bison were intensively hunted by native people and that these ecosystems were structured from the top-down by carnivore and human predation—a factor that must be taken into consideration if free-ranging plains bison are to be reintroduced to Banff and other Canadian national parks (see the next chapter in this volume by White et al.). Furthermore, we suggest that, as a condition of reintroduction, hunting by First Nations may be required to maintain appropriate herd sizes and ecological integrity. This conclusion is in keeping with the recommendations of Parks Canada's recent Ecological Integrity Panel (Parks Canada 2000a-b).

According to that panel, "humans have been present for thousands of years on the lands that now constitute Canada. Their association with the land and their traditional activities were part of the ecosystems and, to a certain extent, made the landscape what it was when Europeans first arrived.... [Moreover] the influence of Aboriginal peoples is fully consistent with ... [the] definition of ecological integrity. [In fact] ... this traditional human role is an important element of the ecological integrity of the ecosystems that Parks Canada is mandated to preserve or restore..." (Parks Canada 2000b, 7-2).

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25 Plains bison restoration in the Canadian Rocky Mountains? Ecological and management considerations

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Introduction

Evaluations of long-term ecosystem states and processes for the Canadian Rockies (Kay and White 1995; Kay et al. 1999; Kay and White, these proceedings) have demonstrated that plains bison *(Bison bison)* were a significant prehistoric and historic component of Banff National Park's faunal assemblage. Bison were eliminated from most their historic range by human overhunting (Roe 1970). The park management plan (Parks Canada 1997) requires an evaluation of bison restoration (Shury 2000). In this paper we summarize some perspectives on the ecological significance of bison, potential habitat use and movement patterns, and implications for management. We conclude by describing the ongoing restoration feasibility study process.

Bison ecological interactions

Bison are the largest North American land mammal and may have had significant ecological effects on ecosystem states and processes where the species occurred. Understanding potential ecological interactions in the Canadian Rockies (Figure 25.1) has provided a focus for interdisciplinary research of archaeologists, anthropologists, and ecologists (Magne et al. 1996; Magne 1999; Kay et al. 1999). Current ecological research is of obvious importance, but it is of necessity carried out on existing circumstances that may not accurately reflect the variety of past ecological conditions. Archaeologically derived data about bison population structure, distribution, diet, and human use can provide important baseline information about bison ecology in the long time period before European intervention (Cannon 2000). Modern bison management should integrate ecological data from both contemporary and long-term approaches.

Humans. In Banff, bison bones have been identified at archaeological sites widely spread apart in time and space throughout the park, although bison are not always the dominant fauna in an assemblage, and bones of any kind are seldom found in abundance (Langemann 2000a-b). Poor bone preservation often impedes identification to a particular ungulate species; mtDNA (mitochondrial DNA) amplification may be able to distinguish ungulate bone fragments (Monsalve 2000), and has the potential to address more detailed questions about bison populations. The earliest known bison occur at the deeply stratified Lake Minnewanka site in Banff (EhPu-1);

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radiocarbon dates of 9990 ±50 BP (year before present; Beta 122723) and 10370 ±60 BP (CAMS 60442) have been obtained on the collagen from bison bone in clearly cultural contexts (Landals 2000). At the Vermilion Lakes site near Banff townsite (EhPv-8), a single bison bone occurred in a component dated to 9930 ±50 BP; however, the dominant fauna in this and the earlier components was mountain bighorn sheep *(Ovis canadensis)*. In the archaeological sites from Waterton Lakes National Park and the Crowsnest Pass, however, bison were consistently the dominant fauna, and bison bones were often found in abundance.

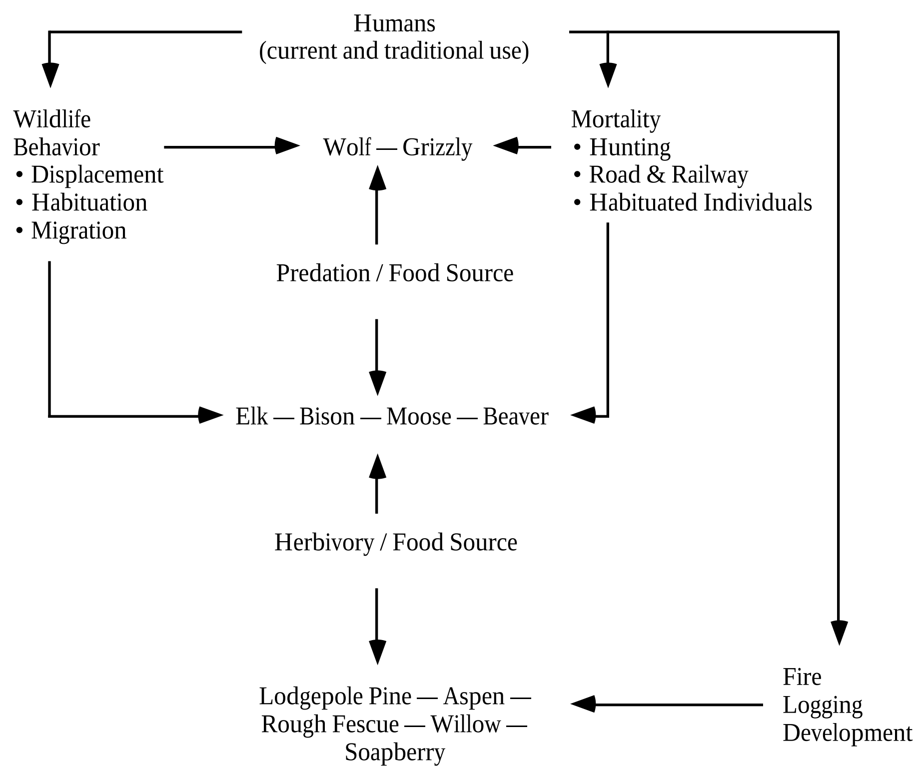

Figure 25.1. Simple trophic model for long-term Rocky Mountain ecosystem states and processes.

Archaeological research demonstrates that the Canadian Rockies were a cultural ecotone that was used as part of the regular seasonal round by a number of different peoples. Throughout the nearly 11,000-year-long record, sites in Banff show alternating influences from both the plateau and plains, in terms of projectile point styles and the source of lithic materials. The number and density of sites also shows that the mountains were intensively used, and were not a marginal no-man's land. The K'tunaxa (Kootenay) and Secwepemc (Salish) peoples have for millennia lived in the mountains, with a seasonal round that included moving across the continental divide between the eastern and western valleys of the mountains (Reeves 2000). Peoples from the plains including the Siksika (Blackfoot), Piikani (Peigan), and, most recently, the Stoney (Nakoda) peoples wintered in the sheltered valleys of the front ranges. In Banff, a series of repeatedly occupied house pit sites in the Red Deer and Bow River valleys suggests the regular use of these valleys over the last 3,000 years by people with cultural ties to the interior plateau of British Columbia. Bison bones have been found in these house pit and earth oven features (Langemann 2000a).

Bison were preferred prey for many First Nations, providing food, clothing, shelter, and tools (Roe 1970; Geist 1996). Human hunting may have been highly effective in virtually eliminating any bison that entered the steep-walled valleys of the Canadian Rockies (Haines 1967; Kay et al. 1999). Although grassland habitat is abundant in intermountain areas to the west, and could have supported abundant numbers of bison, zooarchaeological evidence of bison is scarce (Kay 1994). Kay et al. (1999) proposed that bison persisted in east-slope valleys despite heavy human harvesting because they were sustained by large, migrating herds from the Great Plains. White et al. (2001) suggested that Kootenay and Salish peoples may have even purposely driven bison from the foothills into mountain valleys—in effect using the valleys as giant pounds. Here, bison could be easily found and killed, particularly when snowpacks were deep. In times of conflict, they could have been processed at campsites more secure from Siksika enemies to the east. Further, in the period before horses, hunting bison deep in these mountain valleys would have meant a much shorter distance to pack the dried meat back to the winter camps in the western valleys. Evidence from dendrochronology (White et al. 2001) and ignition studies (Heathcott 1999) indicated that historic east-slope fires were predominantly human-ignited. Burning may have been used by people to maintain grassland areas and movement corridors favorable for bison herds to move into the mountain valleys from the nearby prairies (Kay et al. 1999; White et al. 2001).

Humans, sustained by bison and plant resources, likely affected densities of other large herbivore species (Martin and Shutzer 1999; Kay 2000). The general order of preference by human hunters for ungulates in the mountain areas was probably bison > elk > moose *(Alces alces)* > mule deer *(Odocoileus hemionus)* > bighorn sheep = white-tailed deer *(O. virginianus)*. Historically, elk and moose populations may have been driven to very low densities by human hunting combined with other predation (Kay et al. 1999). Singer and Mack (1999) made similar predictions for elk densities when recreational hunting was combined with wolf *(Canis lupus)* predation in the Yellowstone ecosystem.

Other predators. Wolves, grizzly bear *(Ursus arctos)*, black bear *(U. americanus)*, and cougar *(Felis concolor)* competed with humans for bison and other prey. Joly and Messier (2000) showed that wolf population size was correlated with bison numbers, similar to the numerical response seen in other wolf–prey systems (Packard and Mech 1980; Fuller 1989; Messier 1994). Selectivity by wolves for extant large mammal prey species in the Canadian Rockies is elk >= deer > moose > bighorn sheep (Huggard 1993; Hebblewhite 2000). Bison are less vulnerable to wolf predation than moose (Larter et al. 1994) or elk (Smith et al. 2000). Hebblewhite (2000) observed a steep Type 2 functional response for wolf–elk predation. Bison restoration could thus result in lower densities of more vulnerable prey such as elk or moose, where wolf numbers are sustained by bison, but where wolves prefer to kill more vulnerable prey (Gates and Larter 1990).

Herbivores. Competition between bison and other herbivores has not been studied in ecosystems that include both elk and keystone predators such as wolves and humans. Bison are predominantly grazers (Hudson and Frank 1987), in contrast to browsers such as moose or deer, or the generalist elk (Telfer and Cairns 1979). In a boreal mixedwood system with few predators, sympatric elk and bison both selected upland grassland vegetation types in all seasons (Cairns and Telfer 1980), while moose and deer selected aspen and shrubland types. However, food competition between elk and bison may be minimized because, although these species use the same habitats, the use occurs in different areas at different times (Telfer and Cairns 1979; Wydeven and Dahlgren 1985). Similarly, Singer and Norland (1994) observed only moderate habitat overlap between elk and bison even with high ungulate densities.

The release of herbivores from the long-term effects of human and carnivore predation has restructured Rocky Mountain national park montane ecosystems (Kay 1994; Kay et al. 1999; White et al. 1998; Berger 1999). Elk, normally vulnerable to predation in these systems, have become extremely abundant (Banff–Bow Valley Task Force 1996), and through competition for browse and other interactions may have sharply reduced the abundance of moose (Hurd 1998) and beaver *(Castor canadensis)* (Hess 1993; Nietvelt 2001). Birds may also be affected where release from predation has resulted in high browsing impacts on riparian willows by elk (Nietvelt 2001) or moose (Berger 1999).

Important diseases such as anthrax, tuberculosis, and brucellosis are endemic to certain bison populations in North America. Anthrax, caused by the bacterium *Bacillus anthracis,* is indigenous to North America (Gates et al. 2001). *B. anthracis* persists in neutral-to-alkaline soils in the form of highly resistant endospores (Dragon and Rennie 1995). Outbreaks typically last for six to eight weeks, then may not occur again in the same area for many years (Gates et al. 1995). Bovine tuberculosis exists only in bison populations in and near Wood Buffalo National Park (Tessaro et al. 1990). Bovine brucellosis is present in bison in the Wood Buffalo National Park area (Tessaro et al 1993) and in bison and elk populations in and around Yellowstone National Park (Roffe et al. 1999). Control measures in the Northwest Territories and unrestricted hunting near Wood Buffalo National Park in Alberta reduce the risk of infection of other northern Canadian bison populations (Gates et al. 1992). Bison at Elk Island National Park, location of the Canadian national breeding herds, are tested annually and are negative for both brucellosis and tuberculosis.

Vegetation. Bison effects on vegetation depend on population density (Larson 1940), and foraging and movement patterns driven by predation risk and habitat conditions (Bamforth 1987; Epp 1988; Carbyn et al. 1993). Historic bison densities were likely low in the parklands and Rocky Mountains compared with the nearby prairies (Malainey and Sherriff 1996; Kay et al. 1999). Stable carbon isotopic analysis of bison bone from archaeological sites dating from the last 3,000 years in Waterton Lakes National Park and Banff National Park has shown that all but one of 28 individuals tested obtained at least 10% to 23% of their diet from C4 vegetation. The implication is that even bison found in high-elevation areas and mountain valleys spent some portion of their life in the more xeric prairie, where C4 grasses are present (Langemann 2000b). However, grasslands in which C4 species occur are much closer to the mountains in the Waterton Lakes area than in areas to the north. Bison may have used mountain valley bottoms most often during the fall and winter if they migrated off the prairies into surrounding foothills and aspen parklands (Moodie and Ray 1976), or moved downwards from upper elevations (Meagher 1973; Van Vuren and Bray 1986). This would have favored selection of forage species adapted to relatively low-intensity, dormant-season grazing such as rough fescue *(Festuca saximontana;* Dormaar and Willms 1998). As noted above, the decline of bison and its main predators, and the resulting increase in elk herbivory has resulted in the decline of numerous Rocky Mountain plant species (White et al. 1998) including aspen *(Populus tremuloides;* Kay 1997; White et al. 1998), willow *(Salix* spp.; Nietvelt 2001), and possibly rough fescue (C. White, personal observation).

Fire effects on vegetation communities used by elk and bison were evaluated by Boyce and Merrill (1996), and Singer and Mack (1999) for Yellowstone National Park. Fire-removal of lodgepole pine *(Pinus contorta)* cover was thought to decrease forage availability immediately after burning, but was followed by a period of increase in both graminoid and forb diversity and production. In the absence of limitation by predators, an increase in forage production following burning could support growth in bison and elk populations.

Restoration implications: source or sink population management?

Our review suggests that bison could have been a significant species in the montane ecosystem, interacting with humans, predators, other herbivores, and vegetation. Hence, reintroduction of bison would contribute to restoring the ecological integrity of mountain park ecosystems. Furthermore, historic evidence clearly shows that bison in the Rocky Mountains were at the edge of their western range, and that this range limit was likely human-caused (Haines 1967). Thus, we make the interesting proposition that if bison are restored to this ecosystem, they should be managed as a sink, not a source population.

Sink-population management would require novel techniques for national parks that traditionally have source-population management policies, such as low human predation and encouragement of out-of-park movement of potential dispersers (Caughley and Sinclair 1994; Wagner et al. 1995). Sink-population management techniques might include periodic reduction of bison to very low densities (by traditional human techniques or other predators), routine importing of animals from other populations, and minimal out-of-park dispersal (Soulé et al. 1979; Berger and Cunningham 1994). Research would be required to test the strength of potential regulating factors (Sinclair 1991), and manage for those that likely had greatest long-term effects on bison ecology in mountain environments. For example, Geist (1996) suggested that aboriginal hunters played an important role in developing bison morphology and behavior. Further, bison restoration at its western range limit could provide interesting research opportunities to understand what factors are important at range edges following the methods suggested by Caughley et al. (1988).

Restoration feasibility study process

Parks Canada hosted a Rocky Mountain bison restoration research forum in October 1999 (Shury 2000). Attendees included ecologists, archaeologists, and land managers. Main issues discussed included containment of bison, range carrying capacity, adaptive management approaches, involvement of First Nations, and monitoring and research requirements. A consistent message from provincial land managers was that movements of reintroduced bison on to Alberta lands could cause serious problems related to recreation and agriculture. It was recommended that any trial restorations be restricted to national parks until critical knowledge gaps are addressed.

The group reviewed a proposed future direction and proposed actions. Research is ongoing to provide additional ecological and spatial habitat information that would be used in the next bison restoration feasibility workshop scheduled for January 2002. If stakeholder concerns can be addressed, a trial restoration experiment, with appropriate research design and management controls, would then be developed for further review.

In April 2000, the University of Calgary Faculty of Environmental Design (EVDS) developed a strategic plan for reintroduction of plains bison to Banff National Park (Fleener et al. 2000). The EVDS plan recommended that Parks Canada follow the IUCN guidelines for species reintroductions, including maintenance of genetic integrity, habitat and historic range assessments, and elimination of previous causes of decline.

Both the research forum and EVDS groups recognized that First Nations are critical stakeholders to the bison restoration process. In fact, both groups recognized that the long-term ecological relationships of bison could only be understood in the context of First Nation traditional use and values. The approach of integrating long-term cultural processes into ecological management was also recently recommended by the minister's independent panel on ecological integrity (Parks Canada 2000).

Conclusion

Bison restoration to Canadian Rockies national parks provides an interesting set of challenges that, if surmounted, could help achieve Parks Canada's ecological integrity objectives. First, by restoring a complex set of predator–prey and herbivore interactions, bison reintroduction could help solve a persistent set of problems tied to elk overabundance and intense herbivory. Second, bison restoration as a sink population would encourage managers to develop alternative paradigms than the source population model for wildlife management currently used for Rocky Mountain national parks. Third, the full participation of First Nations in the planning and restoration effort would not only recognize the great historical and spiritual value of bison to their cultures, but also provide a focus on factors such as traditional hunting and burning, likely prevalent in long-term ecosystem states and processes, but largely missing in current management regimes.

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26 Crossing boundaries to increase nesting by Kemp's ridley sea turtles at Padre Island National Seashore and in South Texas

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Introduction

The work to increase nesting by Kemp's ridley sea turtles *(Lepidochelys kempii)* at Padre Island National Seashore and in South Texas is a long-term, multi-faceted, and cooperative effort between the U.S. Geological Survey (USGS), National Park Service (NPS), and a variety of other entities in the USA and Mexico. This work has a focal area at the park. However, since Kemp's ridley is a highly migratory species, it has been necessary that these efforts extend well beyond the boundaries of Padre Island National Seashore.

Kemp's ridley is the most critically endangered sea turtle species in the world. Most Kemp's ridleys nest along the Gulf of Mexico coastline in Mexico, near the village of Rancho Nuevo (U.S. Fish and Wildlife Service and National Marine Fisheries Service 1992). An estimated 40,000 Kemp's ridley females were filmed nesting at Rancho Nuevo on one day in 1947. Unfortunately, by the time that scientists discovered the location of the Rancho Nuevo nesting beach in the early 1960s, the number of nesting Kemp's ridleys had plummeted.

Experimental project

In 1978, it was feared that the Kemp's ridley would become extinct within a few years unless immediate steps were taken. A bi-national, multi-agency effort to save this species was initiated to augment the ongoing research and protection program at Rancho Nuevo. Part of the new effort was an experimental project to establish a secondary nesting colony of Kemp's ridley sea turtles in South Texas at Padre Island National Seashore, where some Kemp's ridley nests historically had been detected.

It was thought that establishing a secondary nesting colony there would provide a safeguard for the species, so that if a political or an environmental catastrophe were to occur in Rancho Nuevo, there would be an area in the USA where Kemp's ridleys could nest and be protected.

For the experimental project, attempts were made to imprint Kemp's ridleys to Padre Island National Seashore in hopes that they would return to South Texas as adults to mate and nest. From 1978-1988, Kemp's ridley eggs were collected in Rancho Nuevo, packed into Styrofoam boxes containing Padre Island sand, and shipped to Padre Island National Seashore for incubation (Shaver 1987; Shaver 1989a-b; Shaver and Chaney 1989; Shaver et al. 1989; Shaver and Fletcher 1992). The resulting hatchlings were released on the beach at Padre Island, were allowed to crawl down the beach and enter the surf, and were captured in the surf using aquarium dip nets. The captured hatchlings were shipped to the National Marine Fisheries Service Laboratory in Galveston, Texas, for rearing in captivity for 9-11 months—an experimental procedure termed "head-starting." Prior to release, each turtle was tagged for future recognition. Tagging methods varied for the different year classes, as new technology developed.

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Detection efforts

The goals of the project now are to determine the results of the above experiment and to foster development of nesting in the area (Shaver 1990; Shaver 1992). The detection program includes extensive public education and outreach to alert beach visitors to report nesting observations—important since visitors report up to half of the Kemp's ridley nests documented on the Texas coast each year.

The detection program also includes daytime patrols via all-terrain vehicles, looking for nesting turtles and their tracks (Shaver 1999; Shaver 2000). A variety of partners are currently cooperating to conduct patrols in south Texas. Patrols began on North Padre Island in 1986. The patrol effort was very limited there prior to 1997 due to a lack of funding, but the effort increased and remained relatively stable during 1998-2000. USGS and NPS staff members and volunteers patrol the entire 128-km length of North Padre Island (including 104 km of Padre Island National Seashore) daily, from at least April through July. Patrols are conducted during daylight hours because Kemp's ridley turtles nest primarily during the day. This area is repeatedly patrolled each day in an attempt to see the nesting turtles, which are only on the beach for 45 minutes during nesting. Observing the nesting turtles enables (1) examination to determine if they are from the experimental project, (2) tagging, and (3) examination for tags to determine nesting chronology. Also, it is much easier to locate the nests for documentation and protection if the nesting turtles are found. Patrols began on South Padre Island in 2000 and on Boca Chica Beach in 1999 and have continued since; these two beaches encompass the area between North Padre Island and the Mexico–USA border.

Nests found

Through 2000, 14 nests found in south Texas were conclusively linked to turtles from the experimental project (Shaver and Caillouet 1998; Shaver 1999; Shaver and Miller 1999; Shaver, in press). These 14 nests were from nine different nesting females that ranged from 10-15 years of age when their nesting was detected. The nine are a minimum estimate of the number of returnees to South Texas from the experimental project. Unfortunately, many of the nesting turtles re-entered the water prior to examination for tags. Also, some nests were likely missed, especially during years when patrol effort was low.

These nine were the first sea turtles of any species that are confirmed to have returned to nest in an area to which they were experimentally imprinted; the first head-started sea turtles of any species confirmed to have nested in the wild; and the first confirmed nestings in the wild by known, aged Kemp's ridley turtles (Shaver and Caillouet 1998). Only one other Kemp's ridley turtle from the experimental imprinting project has been documented nesting in the wild outside of South Texas, and it was found nesting at Rancho Nuevo. Results from this project are being used to evaluate the experimental imprinting and head-starting procedures used, which could have implications for sea turtle conservation worldwide.

During the last two decades, more Kemp's ridley nests have been documented in South Texas than anywhere else in the USA (Shaver, in press), but far more nests have been found in Mexico. Increased numbers of Kemp's ridley nests were found on the Texas coast during five of the six years from 1995 through 2000, with a total of 12 nests documented in Texas in 2000. Recent increases in the number of detected nests could reflect increased nesting by returnees and other turtles not from the project, improved detection efforts, increased awareness and reporting by the public, or a combination of these.

In Mexico, the number of nests documented per year fell to a low point of 702 in 1985, but has climbed since (U.S. Fish and Wildlife Service and National Marine Fisheries Service 1992; Marquez et al. 1999). In 2000, about 6,200 Kemp's ridley nests were found in Mexico, but the area patrolled to detect Kemp's ridley nesting has increased in Mexico during the last decade (Marquez et al. 1999; Rene Marquez, personal communication). Although the Kemp's ridley population is thought to be increasing, the population is still far below former levels and levels at which it can be down-listed or de-listed (U.S. Fish and Wildlife Service and National Marine Fisheries Service 1992).

Satellite tracking

Satellite transmitters are being deployed to track the movements of some Kemp's ridley turtles that nested in South Texas to delineate their movements during the inter-nesting interval and post-nesting. Kemp's ridley turtles nest an average of 2.5 times/year, and one objective of this work is to use tracking data to predict when and where these turtles will nest again, to increase the probability of detecting subsequent nesting. Another objective is to use the data to document where the turtles go between and after nesting, for use by agencies to develop protection strategies for them in the marine environment.

During 1997-2000, 15 transmitters were deployed. Two of the 15 turtles remained in South Texas after the nesting season was completed. The other 13 left South Texas after they were done nesting for the year; these turtles traveled parallel to the coastline and moved to off the upper Texas coast; the coasts of Louisiana, Mississippi, and Alabama; or the west coast of Florida. However, one of the 13 later traveled south to Mexico, then back north to the upper Texas coast.

Egg incubation, hatchling release, and associated data collection

Suspected nest sites are investigated to determine the species involved and to locate eggs. Locating eggs allows documentation of nesting as well as protection of the eggs. Eggs from local beaches are transferred to the incubation facility at Padre Island National Seashore for protected care, where 85% of the eggs typically hatch (Shaver 1992; Shaver 1999; Shaver and Miller 1999; Shaver 2000). In contrast, only 17% of the eggs hatched from the six sea turtle clutches known to have incubated unprotected on Texas beaches during the last two decades. Hatchlings from these nests are released and allowed to go free. When possible, the public is invited to attend these releases, and over 1,000 visitors attended hatchling releases held at Padre Island National Seashore during 2000.

Data are collected from eggs and hatchlings to compare fecundity and vigor for wild versus head-started turtles, develop improved incubation techniques, yield optimum sex ratios, and attain high hatching success.

Stranded adult Kemp's ridley turtles

The Sea Turtle Stranding and Salvage Network was established in 1980 to document strandings of marine turtles in the USA. A stranded sea turtle is one that is found washed ashore dead or alive; most stranded turtles found in Texas are dead by the time they are located. During 1992-2000, more dead adult Kemp's ridleys were found washed ashore on South Texas Gulf beaches than at any other location in the USA (Shaver, in press). These deaths could potentially affect efforts to establish a secondary nesting colony in South Texas.

A variety of human-related and natural factors affect sea turtle survival in the Gulf of Mexico, but incidental capture in shrimp trawls accounts for more sea turtle deaths than all other human activities combined (National Research Council 1990). To decrease this mortality, mandatory use of turtle excluder devices (TEDs) began in U.S. Gulf of Mexico waters in 1990. Despite current mandatory use of TEDs, there continues to be a relationship between Gulf shrimping and strandings on Gulf beaches along the Texas coast (Caillouet et al. 1996; Shaver 1998). The Texas Closure is an annual closure of Gulf waters out to 200 nautical miles off the Texas coast to shrimp trawling from mid-May to mid-July, to allow shrimp to grow larger prior to harvest. Of the 104 adult Kemp's ridley turtles found stranded on South Texas Gulf beaches from 1995 through 2000, 101 were located during times when Gulf waters off the Texas coast were open to shrimp trawling, and only three were found during the Texas Closure.

During 1999-2000, the Texas Parks and Wildlife Department revised their shrimp fishery management plan to develop regulations to help sustain the shrimping industry. The department requested and used nesting, stranding, and satellite tracking data from this work in conjunction with their effort. One of the regulations (passed in August 2000) was the establishment of a shrimp-trawling closure of Gulf waters from the coast to 5 miles offshore from December 1 to May 15 each year. Thus, beginning in 2001, South Texas nearshore waters will be closed to shrimp trawling for the first time during the entire Kemp's ridley mating and nesting seasons. Many biologists hypothesize that this regulation will have side benefits to Kemp's ridleys that are in South Texas to mate and nest, Kemp's ridleys that are migrating to and from Mexico, and other sea turtles. However, this regulation was a compromise between the proposed regulations, desires of various environmental groups, and desires of the shrimping industry. Efforts are underway to evaluate the impacts of this regulation on stranding and nesting levels. If this regulation proves to be beneficial, it could serve as a model elsewhere around the world.

Future work

The project to increase Kemp's ridley nesting at Padre Island National Seashore and in South Texas has been ongoing since 1978. For the foreseeable future, patrols to detect, study, and protect nesting turtles and their eggs. as well as associated outreach activities, will be continued. Work with partners in the USA and Mexico will be continued, but it will be many more years before the results of these efforts are known. Data will be collected and analyzed regarding the results as they pertain to experimental imprinting, head-starting, age to sexual maturity, re-population of the area for nesting, nest number trends, and nest site fidelity, all of which are important in judging the long-term success of our efforts. It would also be beneficial to continue to examine the movements of adult Kemp's ridley females and quantify the impacts of the time and area closure on nesting and stranding levels. Hopefully these efforts will help restore these magnificent turtles so that they can be enjoyed by future generations in both the USA and Mexico.

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27 Nuts and bolts of BAER soil and watershed assessments

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Introduction

Soils and watersheds are two of many resources affected by fire that are evaluated on-site by the Department of the Interior's Burned Area Emergency Rehabilitation (BAER) Team. Fire effects on these resources and potential post-fire conditions and processes may result in adverse community and ecological consequences. The primary purpose for evaluating soils and watersheds is to determine if the fire created emergency watershed conditions. If emergency watershed conditions are found, then the magnitude and scope of the emergency is mapped and described, values at risk are identified, and treatment prescriptions are developed to protect the values at risk. Emergency watershed conditions include both hydrologic and soil factors, typically potential for flash floods and debris flows, and deterioration of soil condition, particularly loss of soil structure that can lead to a decline in soil productivity. On occasion loss of vegetative cover may also contribute to wind erosion. Values at risk include human life, property and critical natural and cultural resources. This paper. based on a poster presented at the conference, highlights the objectives and parameters of the BAER soil and watershed assessment. An accompanying poster highlighted application of treatments.

Common BAER Soil and Watershed Issues

- Threats to human life, property, (e.g. roads, bridges, fences, buildings, recreational facilities, waste and contaminant sites), and resources to be protected (archeological sites, rare, threatened, and endangered species habitat) from fire-related flooding and debris flows.
- Threats to human life, wildlife, and property from falling rock and wind-blown dust (e.g., highway safety conditions).
- Degradation of site productivity for vegetative recovery through loss of ash, soil, and nutrients.
- Threats to water quality, fish, and aquatic resources from nutrient loading and sedimentation.
- Hydrogeologic corrections resulting in large-scale erosion and long-term channel adjustment.

BAER Soil and Watershed Objectives

- Assess fire effects to, determine post-fire condition of, and map burn severity of soils.
- Assess overall changes to soil productivity, hydrologic function, and watershed response to precipitation events in each burned watershed to determine where and what kind of soil and watershed emergencies exist.
- Identify the most critical soil and watershed issues, map their locations, and develop treatment alternatives to mitigate impacts and risks—particularly those that

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pose substantial threats to human life, property, and critical natural and cultural resources—downstream of, as well as within, the burned area.

- Model potential flooding and sediment loss in highly burned watersheds, especially if there are threatened life or property values at risk or resources to be protected.
- Produce a watershed risk/vulnerability map showing source areas of excessive watershed response, flow paths, and potential impact areas.
- Produce a watershed treatment map showing the location of each treatment to be implemented.
- Assist other BAER resource specialists with treatment recommendations to mitigate potential excessive watershed response impacts on other resources (e.g. archeological sites; rare, threatened, and endangered species habitat).

Indicators of Watershed Emergency

Aerial reconnaissance is conducted to identify the spatial distribution and extent of fire severity (canopy condition), burn severity (surface indicators—e.g., color of ash), and values at risk. Field reconnaissance is conducted to evaluate surface and subsurface indicators of burn severity, soil condition, watershed condition, and values at risk. Field evaluations include, but are not limited to:

- Edaphic fire effects (soil productivity);
- Vegetation fire effects: fire intensity and burn intensity;
- Areal extent and strength of hydrophobic soil conditions;
- Mapping burn severity;
- Channel stability or lack thereof;
- Accumulated material within ordinary high water;
- Extent and location of floatable large woody debris;
- Evaluation of mass movement potential;
- Threats to infrastructure from storm flow and debris;
- Current channel and culvert capabilities; and
- Flow routing related to protecting values at risk and critical resources.

"Burn severity" is not the same concept as "fire intensity" and "fire severity" as recognized by fire behavior specialists (see "Some Key Concepts," below). "Fire intensity" relates to behavior of the fire, and "fire severity" to fire effects on vegetation, while "burn severity" relates specifically to effects of the fire on soil conditions and hydrologic function (e.g., amount of surface litter, erodibility, infiltration rate, run-off response). Although burn severity is not primarily a reflection of effects of fire to vegetation, vegetative conditions and pre-fire vegetation density are among indicators used to assess burn severity.

Site indicators used to evaluate and map burn severity include size of residual fuels (fire intensity), ash depth and color (burn intensity), soil texture, and structure and soil hydrophobicity. These criteria indicate fire residence time, depth of litter layer consumed, radiant heat throughout the litter layer, ease of detachability of the surface soil, and soil permeability. Using these indicators, burned areas are mapped as a mosaic of three relative burn severity categories. These include high, moderate, and low/unburned. Because this is a relative scale, it is important that the soil and watershed specialists doing the mapping make time early in the assessment to review the field parameters and calibrate themselves to one another, especially if they have not worked together on previous fires.

In some cases there may be complete consumption of vegetation by fire, with little effect on soil and watershed function. In general, the denser the pre-fire vegetation, the longer the residence time and the more severe the effects of the fire on soil–hydrologic function. For example, deep ash after a fire usually indicates a deeper litter layer prior to the fire, which generally supports longer residence times.

Increased residence times promote the formation of water-repellant layers at or near the soil surface, and loss of soil structural stability. The results are increased run-off and soil particle detachment by water and increased transport off-site (erosion). The presence of white ash indicates a hotter fire and more complete consumption of organic matter. Powdery ash without identifiable remnants of twigs and leaf litter also indicates more complete consumption.

Generally, there is a close correlation between soil properties and the amount of heat experienced by the soil as well as the residence time of the heat in contact with the soil. The burn severity map then becomes a basis to predict the hydrologic response of soil to the fire, and the rate of natural revegetation of the site following the fire.

Mapping is usually done on 7.5-minute U.S. Geological Survey (USGS) quadrangles (1:24,000). It is important to note that burned-area map units are usually mapped at no less than 40 acres in size (about the size of a quarter) and may include areas of other burn severity, but which are too small to segregate. Small areas of different burn severity can therefore be present in each map unit.

Edaphic fire effects are evaluated for several parameters that affect soil conditions. These parameters are hydrophobicity, changes in vegetative ground cover, soil structure, and susceptibility to water erosion. Hydrophobicity is evaluated by observing the depth, thickness, and continuity of a water-repellent horizon in surface soils where it exists, and duration of a water drop beading on this surface. Changes in vegetative ground cover as affected by the fire are noted and compared with pre-fire conditions. Loss of soil structure is usually indicated by a change to a powdery soil. Presence or absence of fibrous roots, fungal mycelium, and seeds in the soil are also noted. Soils susceptible to wind erosion are examined in the field to determine if there is an increased risk of erosion. Soil survey maps and air photos are used to assist in making predictions of areas with the greatest risks of wind or water erosion.

Hydrophobic soils form when soils are heated by fire. This occurs due to volatilization of organic matter in and on the surface soil that have high amounts of lignin and other waxy compounds. After the fire passes, the gasses cool to a waxy coating on soil particles. The effect is similar to putting wax on a car to cause water to bead up and run off. If the hydrophobic layer is thick, or the degree of water repellency is strong, it can seriously inhibit infiltration of rainfall, increase run-off, and detach surface soil particles, all of which increases flooding, erosion, and sedimentation. Some soils can be significantly hydrophobic, even without fire. Vegetation type, amount of organic matter, and soil texture are the primary factors that determine whether or not soils will become hydrophobic.

Watershed response. On-the-ground field observations and aerial reconnaissance are conducted to determine the potential for high run-off response. Channel morphology related to transport and deposition processes are noted, along with channel crossings and stream outlets. Observations include condition of riparian vegetation along seeps, springs, and perennial streams and the potential for vegetation loss and conversion. Burn severity and changes in soil infiltration are considered for run-off potential. Other watershed observations include slope, existing and potential ground cover density (e.g., unburned vegetation, rock fragments, needle cast), and sediment available for transport both on the hillsides and in the channels, to assess watershed response. A literature search of local and regional documented studies is conducted and local scientists and resource specialists are consulted about past watershed responses to wildfires. All of the above criteria are used to identify areas of excessive watershed response that can lead to emergency watershed conditions and threats to life and other resources.

Products

Reports and documents. The soil and watershed assessment is one of many resource elements of the BAER plan. Each resource assessment states its objectives and issues relevant to the specific incident, describes and documents background resource information, field methodology, and findings (including maps, tables, and photos), prescribes treatments to be implemented (including cost analysis and compliance with National Environmental Policy Act and National Historic Preservation Act), and makes other monitoring and management recommendations to the site managers.

Maps. Maps are the key tool used in the gathering, organization, and display of critical information collected by BAER resource specialists. Maps require a scale appropriate for necessary detail, as well as use in a geographic information system (GIS). Typically, we map on standard USGS quadrangles at 1:24,000 scale. Maps produced during the BAER soil and watershed assessment include: observation and data maps (burn severity by watershed, areas of water-repellent soils and potential flood-source areas); analysis/derived maps (watershed risk assessment; pre- and post-fire soil movement / debris flow-source areas); emergency area maps (critical resource areas, flood-prone area); and watershed treatment area maps.

Treatments. Mitigating or warning the public of potential adverse fire effects to soil productivity and excessive watershed response is the goal of the soil and watershed assessment. Watershed stabilization treatments may be applied to hillslopes and channels. It is important to understand that BAER cannot design treatments to protect against all scales of floods and other mass movement events. Treatments applied to burned watersheds are most effective in mitigating two- to ten-year storm events. Storms smaller in magnitude than a two-year event usually do not affect a burned watershed sufficiently to necessitate treatment. Storms generally greater than a ten-year event may create a run-off response in excess of one or two orders of magnitude. Watershed stabilization treatments are often ineffective under such conditions. Other BAER soil and watershed recommendations include installing remote weather stations and hazard warning signs at critical sites, and monitoring storms and changes in resource condition.

Some Key Concepts

Burn intensity accounts for fire effects on understory (ground) vegetation and soils (burn severity). Measured in BTU/minute/ft, burn intensity depends upon moisture content of duff and large fuels (lying on the ground). It accounts for the amount of conductive and radiant heat that goes down into the soil. The amount of duff consumed and depth and color of char and ash are visible indicators. Burn intensity is difficult to measure and is qualitatively defined on a relative post-fire burn severity scale: low (or partial consumption) = black ashes; moderate = gray or mixed ashes; high = white or red ashes. Finally, burn intensity is in part defined by its effect on ecosystems, e.g. a function of plant responses to fire.

Burn severity is a relative measure of the degree of change in a watershed that relates to the severity of the effects of the fire on soil and watershed conditions. It is delineated on topographic maps covering the area of the fire as a mosaic of polygons labeled high, moderate, and low burn severity.

Emergency watershed condition refers to the existence of watershed conditions in which processes can accelerate in response to fire effects on the watershed leading to excessive watershed/hydrologic response.

Excessive watershed/hydrologic response occurs when watershed functions, such as run-off and sediment yield, will approach the upper limit of the natural range of variability of the stream channel, and may exceed our ability to protect the values at risk from accelerated water yield (floods), release of stored sediments (mud and debris flows), and degraded water quality (suspended sediment and chemical enrichment from ash).

Fire intensity accounts for fire effects on overstory vegetation (fire severity). Measured by the rate of heat release (from combustion) per unit time per unit length of fire front (BTU/sec/ft), fire intensity depends upon (a) rate of spread, (b) heat of combustion, and (c) total amount of fuel consumed (flame length, violence, temperature, destructive energy of the fire). It accounts for convective heat rising into the atmosphere (outward heat flow). Flame length and size of residual fuels are visible indicators. Fire intensity is defined on a relative scale: low = up to 0.25-inch diameter fuels consumed; moderate = greater than 0.25-inch, but less than 0.75-inch fuels consumed; high = fuels 0.75-inch diameter and larger consumed.

Common Watershed Treatments	
Hillslope treatments · Aerial / hand seed · Contour rake · Contour tree fall · Directional tree fall · Log erosion barriers · Hydromulch · Straw mulch · Straw wattles	*Channel treatments* · Armor stream crossings · Clean out catchment basins · Clean out culverts · Construct sediment traps in tributary channels · Install stream grade control structures · Protect wellheads, power poles, and archeological sites from flooding and debris · Remove floatable debris from channels and floodplains
Life and safety measures · Install flood-hazard safety signs along roads, trails, campgrounds, and picnic areas · Install RAWS	*Monitoring specifications* · Assess structures at flood risk · Monitor water quality · Monitor storm flows and sediment transport

Fire severity is a relative measure of the degree of change in overstory vegetation caused by fire intensity; usually referred to in terms of low, moderate, or high fire severity.

Hydrophobicity is the water repellency of soils affected by fire. Waxes released from volatilized organic matter move downward into the soil and condense around individual soil particles to form a water-repellent layer which restricts water movement. Soil penetration may be a few millimeters to several centimeters below the surface and the impervious barrier may be a few centimeters thick. Site conditions favorable for hydrophobic development include: high fire severity, long fire residence time, deep leaf-litter layer consumed by the fire, high burn severity, and coarse-grained soils (permeable for liquefied waxes). The depth and thickness of the barrier is determined by a water-drop penetration time test. The longer the duration or greater the depth, the greater the potential watershed response; this relates to storm intensity and duration.

Values at risk are those which are vulnerable to impact from excessive watershed response due to loss of control of water on-site, in-stream or downstream (fire- or burn-caused hydrologic or geologic events). These values include on-site and in-stream site productivity, and on-site and downstream threats to human life, property, and natural and cultural resources.

The ***water-drop penetration time test*** is a relative measure of hydrophobicity by timing the duration of a water drop beading on and penetrating exposed soil after gently scraping ash away from the surface, and at successive depths in the soil. The U.S. Forest Service classification standard is: less than 10 seconds = weak hydrophobicity; 10-40 seconds = moderate hydrophobicity; longer than 40 seconds = strong hydrophobicity.

28 Our public lands in twenty years: national parks or amusement parks?

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To conserve the scenery and the natural and historic objects and the wildlife therein, and to provide for the enjoyment of the same in such a manner and by such means as will leave them unimpaired for the enjoyment of future generations.

— National Park Service Organic Act (16 U.S. Code, Sec. 1)

Introduction

A few years back, my wife and I visited Lake Powell at Glen Canyon National Recreation Area on the Arizona–Utah border. At the park's entrance station, the park ranger staffing the kiosk handed us several materials, which I assumed were National Park Service (NPS) brochures and maps. Unfortunately, the materials were private advertisements for the many commercial services available at the park. The cover of one of the brochures proudly proclaimed that Lake Powell is "America's Playground." Inside, no mention was made of the need for resource protection or the conservation mission of NPS. Rather, my wife and I were encouraged to take part in questionable activities such as riding jet skis. The brochure proudly put forth that one should "raise your heart rate" on the thrill-craft.

To some, forfeiting of Lake Powell to the motorized thrill-craft industry is no great loss. However, to others it signals that the Park Service may be losing sight of its paramount mission to leave the park system's resources and wildlife "unimpaired for the enjoyment of future generations."

The battle to determine the appropriateness of jet skis, snowmobiles, and off-road vehicles in the National Park System is part of a much larger struggle over what type of vision will determine the future of national parks like Yellowstone, Glacier, and the Everglades. Will our national parks remain those sites where America protects some of its most sacred ideas, hopes, and places, or will they be allowed to degrade into nothing more than motorized amusement parks?

Unimpaired Mandate

In 1872, Yellowstone became the world's first national park. It was created for the benefit and the enjoyment of the American people. Forty-four years later, Congress passed the Organic Act, which mandated that present enjoyment must leave park resources "unimpaired for the enjoyment of future generations." By passing the Organic Act, Congress declared that forms of recreation which cause lasting damage to park resources are inappropriate for the National Park System.

The vast majority of America's public lands are managed under the multiple-use doctrine. This means that federal land mangers, such as those in the U.S. Forest Service, must accommodate multiple uses such as recreation, logging, and wildlife conservation on these lands and waters. In contrast, Congress has set aside a small

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portion of the U.S. landscape—roughly 5%—for special protection within the National Park System (NPS 2001). These areas were selected because they contain unique, nationally significant, ecologically sensitive and irreplaceable resources—such as the Grand Canyon or the giant Sequoias of Kings Canyon and Sequoia national parks.

From the Organic Act mandate, it is apparent that Congress exempted the Park Service from the multiple-use doctrine and clearly instructed the agency to authorize only those uses and activities which leave park resources unimpaired. The Park Service appears to understand this limitation and, over time, it has phased out popular, although highly questionable, activities such as Yellowstone's bear shows and Yosemite's fire falls (Sellars 1997). However, in recent years, public lands have seen a flood of new, higher-impact activities, such as the use of motorized thrill-craft (i.e., jet skis, snowmobiles, and off-road vehicles). In the USA alone there are roughly 5 million thrill-craft, with an additional 500,000 new units sold every year.

Given the congressional limits on what activities the Park Service can authorize, a growing list of concerned citizens are questioning the appropriateness of motorized thrill-craft in the Park System. Why?

Motorized thrill-craft cause impairment

Countless studies have documented the significant damage motorized thrill-craft cause to air and water quality, cultural resources, soils and soil stability, private property, visitor enjoyment, public health and safety, natural quiet, and wildlife. For example, the majority of thrill-craft on the market today are powered by conventional two-stroke engines. These motors dump between 25 and 30 percent of their gas and oil mixture unburned into the environment (EPA 1996). At Yellowstone and Grand Teton national parks, for example, it has been estimated that one winter season's snowmobile traffic dumps approximately 100,000 gallons of unburned fuel onto the parks' snowpack and water bodies (Bluewater Network 1998). In addition, these engines expel pollutants that have detrimental impacts upon plants and wildlife. A study of Lake Tahoe found that marine outboard motors produce polycyclic aromatic hydrocarbons (PAHs), which are toxic to aquatic plants and fish even at minute levels—parts per trillion (Oris 1998).

Research is also revealing that motorized thrill-craft have a negative impact upon wildlife. For, example, the U.S. Fish and Wildlife Service is concerned about snowmobile activity and its impact upon the long-term survival of the endangered Canada lynx. Snowmobile operation, especially off-trail use, leaves tracks which provide other predators such as the coyote or bobcat access to hunting grounds that were previously the sole domain of the lynx. These new predators place stress upon the survival of the lynx by reducing the overall prey base (USFWS 1998).

For more on the impact motorized thrill-craft have on the environment, please see Bluewater Network's Web site: www.bluewaternetwork.org.

Caught off guard?

Unfortunately, the exploding numbers of motorized thrill-craft seem to have caught the Park Service off-guard. At several parks, thrill-craft use is becoming well entrenched. Furthermore, new thrill-craft, such as the solo water-ski machine and the motorized all-terrain dirtboard, are continually being brought to market.

On a positive note, throughout the past several years NPS has begun measures to rein in thrill-craft damage. For example, last year the agency finalized regulations that prohibit jet ski operation in all but 21 national parks (36 Code of Federal Regulations Sec. 1, 3.13). At Yellowstone and Grand Teton, the agency has begun phasing out snowmobile operation, replacing it with a cleaner and quieter mass-transit system (*Federal Register*, 22 January 2001). Finally, at Big Cypress National Preserve, NPS recently completed a long-overdue management plan designed to protect the preserve from off-road vehicle damage (NPS 2000a).

Disturbing trends

Sadly, despite strong public support for these measures, the thrill-craft industry is unleashing its well-financed lobbying machinery in an attempt to block further implementation. With a new administration in the White House, some of industry's schemes appear to be gaining traction. For example, industry lawyers are meeting behind closed doors with Department of Justice lawyers in the hopes of reaching an out-of-court settlement that would bar enforcement of snowmobile bans at Denali and Yellowstone National Parks (CNN 2001).

What should be done to protect the parks?

Given the recent change in administration, it is highly unlikely that new national initiatives dealing with motorized thrill-craft will be forthcoming anytime soon. However, even in this political climate there is much individual park units can and must do regarding motorized thrill-craft activity.

Take stock of recreational use. In the Park Service's 2001 management policies, the agency states that those recreational activities not mandated by law will only be allowed if "they are appropriate to the purpose for which the park was established and they can be sustained without causing unacceptable impacts to park resources" (NPS 2000b). To comply with this goal, the Park Service should collect baseline data on the types and amount of recreational use currently taking place at each park unit. Collection of this data could be incorporated into future park management processes, such as the revision of a general management plan.

Once the data have been reviewed, an environmental analysis should be initiated for those forms of recreation that are believed to pose a potential threat to park resources and values. If the analysis determines that the activity is causing impairment to park resources, mitigation measures, including prohibition if necessary, must be implemented.

Monitor impacts. Last year, the General Accounting Office (GAO) released a report regarding the management of motorized thrill-craft by the four major federal land-management agencies (U.S. Forest Service, Bureau of Land Management, USFWS, and NPS). In the report, the GAO found that these agencies have collected very little information on thrill-craft use or its impact upon federal resources (GAO 2000). This lack of information is particularly troubling given the fact that President Richard Nixon's Executive Order 11644 requires federal agencies to monitor thrill-craft impacts on federal lands and waterways (Nixon 1972). Without this information, it is impossible for land management agencies to make sound management decisions. At a minimum, at those park units that currently experience motorized thrill-craft use (both legal and illegal), the Park Service should immediately set up monitoring programs, paying particular attention to the machines' impact upon air and water quality, visitor enjoyment, public health and safety, natural quiet, soils and soil chemistry, cultural resources, and wildlife.

Take proactive measures. Besides barring impairment of park resources, federal law also empowers the Park Service to take proactive measures to protect park resources and wildlife. Superintendents at dozens of park units have used the power afforded them in the Superintendent's Compendium to close their waters to jet skis. Superintendents at other park units are encouraged to use the compendium in a similar fashion.

Provide and promote opportunities for contemplative recreation. In 1898, John Muir wrote: "Thousands of nerve-shaken, overcivilized people are beginning to find out that going to the mountains is going home: that wildness is a necessity; and that mountain parks and reservations are useful not only as fountains of timber and irrigating rivers, but as fountains of life." Many Americans share Muir's belief that the best way to escape life's pressures is through such contemplative forms of recreation as hiking, wildlife viewing, and seeking solitude. A recent surveyed conducted by the state of Washington found that, out of 15 potential activities, more contemplative forms of recreation, such as walking and hiking, were the most popular across nearly all age groups. In contrast, operating off-road vehicles rated near the bottom with other activities such as hunting and hang gliding (State of Washington 2001).

Unfortunately, due to the noise, stink, and pollution of motorized thrill-craft, it is often impossible for other park visitors to engage in more contemplative forms of recreation. Furthermore, these visitors must venture further into the backcountry to escape the mechanized onslaught of off-road vehicles. At Yellowstone, for example, it was discovered that snowmobile noise can be heard up to ten miles away from snowmobile trails. In addition, newer thrill-craft are more powerful and reliable than models made just a few years ago. As a result, new areas once thought inaccessible to thrill-craft are now seeing the machines. This in turn means that there is a diminishing number of wild places which allow the public an escape from everyday life.

In contrast, according to the GAO, thrill-craft riders enjoy a disproportionate amount of access to federally managed lands and waters (GAO 2000). In particular, the GAO found that, despite that fact that thrill-craft operators represent less than 2% of the visiting public, their machines are permitted on or in roughly 50% of all federally managed waters and lands. Therefore, prohibiting thrill-craft from the national parks will not significantly reduce the number of areas where users currently operate their machines. However, a ban on the machines will greatly increase the number of areas that can provide opportunities for contemplation.

Protect the aura of the parks. Ultimately, it appears that the motorized thrill-craft industry fails to comprehend the spirit and purpose of the National Park System. Advertisements which state that "Scenery's for saps," or, "Be on a first-name basis with the sound barrier," flaunt the industry's belief that public lands such as the national parks are just another place for riders to exploit in search of further thrills. These ads promote a vision of the parks that reduces the awe-inspiring setting of the Grand Canyon, or the magnificent lakes of Glacier, to the status of side shows at an amusement park.

The National Park System is much more: it symbolizes our national heritage. As such, is has become wrapped in a special "aura."

Recreational activities can either enhance or detract from this aura. Over the years, the Lincoln Memorial has developed a special "feel" which honors not only President Lincoln but also other great Americans, such as Martin Luther King. For some, the memorial's steps, railings, and smooth surfaces present an ideal environment for skateboard riding. However, the Park Service correctly understands that skateboarding in the Lincoln Memorial would belittle the values and purposes for which it was established. Skateboarding would also severely diminish the experience of many visitors. Therefore, the Park Service has barred skateboarding and similar athletic activities from the National Capital Parks (36 CFR Sec. 7.96).

Conclusion

Just like skateboarding in the Lincoln Memorial, motorized thrill-craft at parks such as Yellowstone, Big Cypress, and Lake Mead are detracting from Park Service values and diminishing the enjoyment of other visitors. Since damage to park resources may not always be reversible, the Park Service would be wise to err on the side of caution when managing these questionable activities. Bluewater Network believes that NPS would go a long way toward achieving its paramount mission of leaving the National Park System unimpaired for the enjoyment of present and future generations by banning these machines.

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29 Federal lands: agencies need to assess the impact of personal watercraft and snowmobile use

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Many of our national parks, forests, wildlife refuges, and other federal lands are a potential source of recreational opportunities for the estimated 14 million adults who used (in 1999) a personal watercraft, such as a jet ski, or a snowmobile. However, the recreational use of these vehicles is often criticized as causing damage to plants, wildlife, and other resources, as well as creating safety problems and conflicts with other visitors to federal lands. Determining the extent to which these vehicles should be allowed to operate on these lands is a contentious and challenging issue faced by federal land managers.

Although this issue draws considerable attention, relatively little reliable information has been assembled about the extent to which personal watercraft and snowmobiles are used on federal lands, the process by which decisions about their use are made, or the extent of monitoring being done in areas where their use is allowed. As a result, U.S. Representatives Bruce Vento and George Miller asked the U.S. General Accounting Office (GAO) to examine the following questions:

- To what extent are personal watercraft and snowmobiles used in federal units?
- What are the bases for agency decisions to authorize or prohibit the use of these vehicles?
- In federal units where their use is allowed, do restrictions exist on operations, and how are these restrictions enforced?
- To what extent have these federal agencies assessed the impact of such use?

The study reviewed use of personal watercraft and snowmobiles on lands managed by four major federal land management agencies—the Bureau of Land Management, the U.S. Fish and Wildlife Service, and the National Park Service in the Department of the Interior, and the U.S. Forest Service in the Department of Agriculture. To respond to these questions, GAO asked managers from each of nearly 1,200 federal units within the four agencies to answer a questionnaire via the Internet. These units include the lands and waters in such areas as national parks and monuments, national forests and recreation areas, wildlife refuges, and grasslands. Managers from more than 85% of these units responded. The questionnaire asked, among other things, about whether lands or bodies of water in their unit had the capacity for personal watercraft or snowmobile use; if so, whether prohibitions or restrictions were in place; and what information, if any, was available on the impacts of recreational use of these vehicles. In our questionnaire, we defined "capacity for use" as follows: for snowmobiles, it meant having suitable terrain and sufficient snow depth in an average year to operate these vehicles within a federal unit; for personal watercraft, it meant having any water on or adjacent to the lands administered by the federal unit that support or could potentially support their use. The resulting information, while not inclusive of every unit, is nonetheless more comprehensive than any other information available.

From **Crossing Boundaries in Park Management: Proceedings of the 11th Conference on Research and Resource Management in Parks and on Public Lands,** edited by David Harmon (Hancock, Michigan: The George Wright Society, 2001).

Background

In 1999, an estimated 10 million adults used a personal watercraft and an estimated 4 million adults used a snowmobile in the USA. Personal watercraft—often called by such names as "jet ski" and "waverunner"—are high-performance watercraft operated by a person sitting, standing, or kneeling on the vessel rather than sitting within the confines of a hull. The watercraft are highly maneuverable and are often used to perform stunt-like maneuvers. Some personal watercraft are capable of speeds exceeding 60 miles per hour. Snowmobiles allow users to travel across the snow into remote areas; some are capable of speeds exceeding 80 miles per hour.

The use of personal watercraft and snowmobiles has raised concerns about their impacts on the environment, public safety, and conflicts with other users. For example, according to studies by the U.S. Environmental Protection Agency and other federal and state agencies, both types of vehicles discharge up to 25-30% of their fuel (a combination of oil and gas containing numerous toxic compounds) unburned into the environment. Other studies have shown that the rapid movement and noise from these vehicles stresses wildlife. For example, researchers at Great White Heron National Wildlife Refuge in the Florida Keys noted that disturbances by personal watercraft contributed to poor reproductive success of nesting ospreys. Concerns have also been raised about the safety record of both personal watercraft and snowmobiles. For example, while personal watercraft make up less than 10% of the motorized boating vessels registered in the USA, they constitute approximately 40% of the vessels involved in accidents. Furthermore, on average, over 13,000 people are treated in emergency rooms for snowmobile injuries each year. In addition, some federal units have reported that the use of personal watercraft and snowmobiles has caused conflicts with other users of federal lands. For example, at the Deschutes National Forest in Oregon, Forest Service officials noted that a dramatic increase in both snowmobile use and nonmotorized uses, such as cross-country skiing and snowshoeing, created a conflict between these users for access to forest trails.

According to industry representatives, personal watercraft and snowmobiles currently being manufactured meet existing noise standards and either meet existing air quality standards or are only small contributors to air pollution nationwide. These representatives noted that manufacturers are also attempting to further address pollution and noise concerns through technological developments in engine design—producing more efficient, cleaner, and quieter machines. Furthermore, according to industry representatives, manufacturers are promoting safer vehicle operation. For example, representatives of the Personal Watercraft Industry Association said the association is promoting safety standards, including a minimum age requirement of 16 years old to operate personal watercraft. Similarly, the International Snowmobile Manufacturers Association has led campaigns to educate users on the safe operation of snowmobiles. In addition, both associations support buffer zones or trail designs that help to protect sensitive environmental areas and wildlife.

Principal findings

In fiscal year 1999, personal watercraft, snowmobiles, or both were used for recreation in 475 of the 1,018 (47%) federal units that responded to our questionnaire. This rate varies by agency, from 31% of the units managed by the National Park Service to 82% of units managed by the Forest Service. Personal watercraft are used in more federal units than are snowmobiles. Although personal watercraft and snowmobile users constitute a relatively small portion of total visitors to most units, during some seasons they may represent a significant portion of the total number of visitors to some units. For example, in Yellowstone National Park, snowmobile users make up more than 43% of the park's winter visitors (Table 29.1).

Several factors determine whether personal watercraft or snowmobile use is permitted in a particular federal unit, including specific provisions in law and an agency's regulations and policies. Specific provisions in federal law prohibit the use of these vehicles in some locations, such as wilderness areas, and specifically authorize their use in others, such as national recreation areas. If no laws specifically prohibit or authorize use, the federal agency responsible for managing the land and water makes such a determination, generally on a unit-by-unit basis. Regulations and policies for these use determinations differ substantially among the four agencies. The Park Service and the Fish and Wildlife Service generally disallow the recreational use of these vehicles unless it can be demonstrated that no harm would be likely to result to the unit's resources and environment. In contrast, the Forest Service and the Bureau of Land Management generally allow their use unless the unit manager clearly demonstrates potential harm. These contrasting policies result in markedly different percentages of units in which usage is prohibited (Table 29.2).

Agency / number of units responding to survey	*Number of units reporting use*			
	PWC only	*SNMB only*	*PWC & SNMB*	*Total / Percentage*
Bureau of Land Management (n=103)	23	21	35	79 (77%)
USFWS (n=419)	93	49	16	158 (38%)
NPS (n=328)	52	37	12	101 (31%)
U.S. Forest Service (n=168)	28	26	83	137 (82%)
Total (n=1,018)	*196*	*133*	*146*	*475 (47%)*

PWC = personal watercraft; SNMB = snowmobiles. "Use" includes both authorized and unauthorized use.

National Park Service officials noted that the number of units reporting use of snowmobiles exceeded the number of parks where such use is authorized for a number of reasons, including use on nonfederal lands, such as county and state roads, located within a unit. Furthermore, in the case of personal watercraft, NPS officials noted that the units reported use that occurred prior to the Park Service's April 2000 regulation that prohibited, pending further evaluation, personal watercraft in all but 21 parks.

Table 29.1. Extent of use, by agency and vehicle type, Fiscal Year 1999.

Agency / number of units with capacity	*Number of units reporting total prohibitions*			
	PWC only	*SNMB only*	*PWC & SNMB*	*Total / Percentage*
Bureau of Land Management (n=90)	2	0	0	2 (2%)
USFWS (n=350)	127	37	56	220 (63%)
NPS (n=182)	66	33	13	112 (62%)
U.S. Forest Service (n=155)	28	4	1	33 (21%)
Total (n=777)	223	74	70	367 (47%)

PWC = personal watercraft; SNMB = snowmobiles. Agencies may not have clear authority to prohibit use in all areas of their units where the capacity for use exists.

Table 29.2. Total prohibitions of use by agency and vehicle type.

Other factors also determine whether use will be allowed or not. For example, in certain cases, federal agencies defer, primarily to states, the decision about whether or not to allow personal watercraft of snowmobile use in all or part of an individual federal unit. In other cases, a state may have some authority to make this decision, such as through an easement or right-of-way agreement. In all, entities other than the federal agency make the decision in more than half of the units on which usage is allowed (Table 29.3).

Agency / number of units with use	Number of units reporting lack of authority			
	PWC only	SNMB only	PWC & SNMB	Total / Percentage
Bureau of Land Management (n=79)	48	5	6	59 (75%)
USFWS (n=158)	74	11	24	109 (69%)
NPS (n=101)	28	11	4	43 (43%)
U.S. Forest Service (n=137)	67	3	19	89 (65%)
Total (n=475)	217	30	53	300 (63%)

PWC = personal watercraft; SNMB = snowmobiles.

Table 29.3. Units reporting the lack of authority to control use.

Approval for recreational use of personal watercraft or snowmobiles on federal lands generally comes with restrictions. For example, use might be limited to certain times or areas, and operators might have to meet certain age requirements or observe certain speed limits. In most cases the restrictions come from state laws and regulations that have been adopted by the federal agency or an individual unit. In many cases, enforcement actions are a shared responsibility among federal, state, and local officials. Even with this shared responsibility, however, a significant number of federal units reported that enforcement activity was limited because of personnel shortages.

Managers of individual federal units often do not have any information on the impacts of personal watercraft and snowmobiles on their unit's resources and environment. A variety of laws and executive orders authorize the federal land management agencies to monitor the impact of using recreational vehicles on natural resources, safety, and other users of federal lands and waters. However, about 60% of the federal units that have use reported that they have not collected information on the effects of that use. In addition, of the remaining 40% that have collected such information (Table 29.4), about half said the information was not adequate for determining how personal watercraft and snowmobile use should be managed. When federal land management agencies and others have completed studies on the impact of personal watercraft and snowmobile use, the results have raised concerns about their adverse effect on the environment, public safety, and conflicts with other users. Agency officials generally attributed this lack of information to the low priority the agencies have given to monitoring the effects of these vehicles. According to officials of all four agencies, monitoring has received a low priority because, historically, only a few units have experienced intensive use of these vehicles.

Conclusions

Among the four major federal land management agencies, the National Park Service has done the most to control the use of personal watercraft and snowmobiles within its units. Recently, the Park Service has issued stricter policies on where personal watercraft and snowmobiles can and cannot be used within its units. Also, the Park Service (for both types of vehicles) and the Forest Service (for snowmobiles) have recently emphasized that existing executive orders, regulations, and laws require the monitoring of these vehicles' impacts where use is allowed. However, each of the four land management agencies has continued to allow the use of these vehicles in many of its units with little or no information on the effects, if any, these vehicles have been having on its units' resources and environment. While we recognize that the agencies have limited resources, in our opinion it is difficult to properly manage the use of these vehicles if units have no or inadequate information on their impact. Furthermore, without such information, these agencies are not in compliance with the monitoring requirements of existing executive orders concerning snowmobiles and, concerning personal watercraft, are not assured that they are fulfilling their responsibility to protect the lands and waters they manage from adverse impacts. Because the type and extent of information needed to adequately monitor the use of these vehicles is not clearly defined in existing executive orders, regulations, and laws, federal land management agencies have the flexibility to design monitoring requirements that fit the needs of their individual units. These requirements can range from detailed scientific studies that could be applied to all units (such as studies of vehicle emissions) to individual staff observations. However, it is essential that each agency and its unit managers have enough information to make knowledgeable decisions about the recreational use of these vehicles.

Agency / number of units with use	*Number of units reporting some information collected*		
	Studies at the unit or elsewhere	*Personal observations only*	*Total / Percentage*
Bureau of Land Management (n=79)	4	20	24 (30%)
USFWS (n=158)	9	43	52 (33%)
NPS (n=101)	25	30	55 (54%)
U.S. Forest Service (n=137)	26	54	80 (58%)
Total (n=475)	64	147	211 (44%)

Table 29.4. Information on impacts, by agency and by type of information.

Recommendations

GAO recommended that the Secretaries of the Interior and of Agriculture ensure that, where snowmobile and personal watercraft use occurs on federal lands, agencies under their jurisdiction monitor such use to determine what impact, if any, these recreational vehicles are having on natural resources, public safety, and the visiting public. This monitoring should be designed to provide sufficient information to make knowledgeable decisions on the impact of these vehicles in individual units. In addition, once this information is collected, it should be used in any future decisions on whether personal watercraft and snowmobiles are to be allowed on federal lands and waters, and if so, how their use should be managed.

30 Winning and losing in court: the great Denali snowmachine debate

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Introduction

The Denali snowmobile case is one in which very different visions for the park collide. Some snowmobile users, for example, view the park interior as having value only if people can get there to see it, including during winter. Other park users advocate protecting natural sounds and places where people don't go and view the interior of Denali as a wildlife refuge.

Protecting the more intangible values of Denali National Park and Preserve is not a new idea. In working during the early 1900s to establish Mount McKinley National Park, Charles Sheldon wrote of attributes such as intact natural systems, solitude, and self-reliance, in addition to wildlife protection. The first superintendent of the park, Harry Karstens, captured the essence of the wilderness in the park with a statement during the 1920s: "There is much to offer those who understand the language of the great silent places, the mighty mouthed hollows, plumb full of hush to the brim" (Brown 1993).

Background

Denali National Park and Preserve is located in south-central interior Alaska and includes over 2.4 million ha (6 million acres). Approximately one-third of the area is designated wilderness (Figure 30.1). The primary access into the park interior is on a tour bus, visitor transportation shuttle bus system, or by bus to a Kantishna area lodge. This controlled access system has been in place since 1972 and has been a significant factor in protecting resource values and the visitor experience in Denali.

Denali is an internationally significant protected area that has been proclaimed a biosphere reserve under the United Nations Man and the Biosphere program. Wilderness is a fundamental value identified with Denali at its establishment, and this value has been reaffirmed throughout the administrative history of the park.

Congress established Mount McKinley National Park in 1917 to "set apart as a public park for the benefit and enjoyment of the people . . . for recreation purposes by the public and for the preservation of animals, birds, and fish and for the preservation of the natural curiosities and scenic beauties thereof . . . said park shall be, and is hereby established as a game refuge" ("An Act to Establish the Mount McKinley National Park, in the Territory of Alaska," 39 Stat. 938).

The Alaska National Interest Lands Conservation Act (ANILCA; 94 Stat. 2371) of 1980 expanded Mount McKinley National Park from 2 million to 6 million acres and renamed it Denali National Park and Preserve. Almost all of the former Mount McKinley National Park was designated as wilderness.

ANILCA contains language defining the broad purposes of the new national parks and preserves in Alaska as well as the specific purposes of each conservation unit, including Denali. The primary purposes of the new and enlarged national parks and preserves in Alaska, such as preserving extensive, unaltered ecosystems in their natural state, are included in Section 101. Section 202 includes language specific to Denali National Park and Preserve:

From **Crossing Boundaries in Park Management: Proceedings of the 11th Conference on Research and Resource Management in Parks and on Public Lands,** edited by David Harmon (Hancock, Michigan: The George Wright Society, 2001).

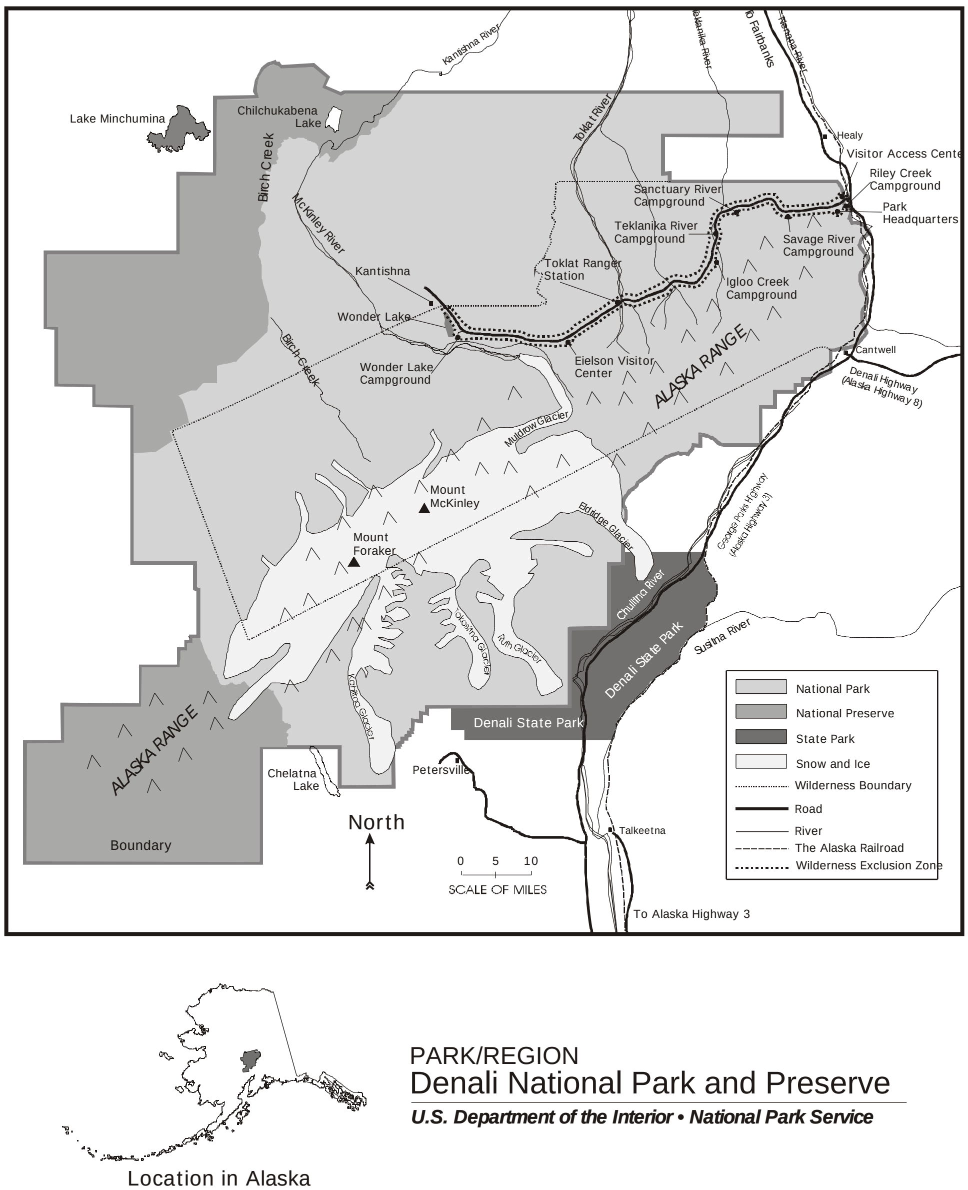

Figure 30.1. Denali National Park and Preserve.

- To protect and interpret the entire mountain massif and the additional scenic mountain peaks and formations.
- To protect habitat for, and populations of fish and wildlife including, but not limited to, brown/grizzly bears, moose, caribou, Dall sheep, wolves, swans, and other waterfowl.

· To provide continued opportunities, including reasonable access, for mountain climbing, mountaineering, and other wilderness recreational activities.

The law also contains language providing for motorized access to traditional activities. Section 1110(a) states:

> ... the Secretary shall permit ... the use of snowmachines (during periods of adequate snow cover, or frozen river conditions in the case of wild and scenic rivers), motorboats, airplanes, and nonmotorized surface transportation methods for traditional activities (where such activities are permitted by this Act or other law) and for travel to and from villages and homesites. Such use shall be subject to reasonable regulations ... to protect the natural and other values ... and shall not be prohibited unless, after notice and hearing in the vicinity of the affected unit or area, the Secretary finds that such use would be detrimental to the resource values of the unit or area.

History of snowmobile use in Denali National Park and Preserve

The designated wilderness, or "old park" of Denali National Park and Preserve, has a long history of non motorized use, with winter access primarily by dogsled, skis, and snowshoes. Mechanized equipment was not used by the general public during the winter from the time Mount McKinley National Park was established in 1917 to 1970 because of the remoteness of the area and the lack of dependable equipment (NPS 1999a).

Mount McKinley National Park was officially closed to snowmobile use in 1970 by a nationwide regulation applying to many park units. From 1970 to 1980, illegal snowmobile travel into the park was sporadic. However, as snowmobile technology advanced significantly during the 1980s and 1990s, more individuals began to use the lands in and near the newly designated Denali National Park and Preserve for snowmobiling (NPS 1999a).

The legislative history of ANILCA indicates that this rapidly expanding level of snowmobile use was unanticipated when the law was written. The Senate committee report in 1979 stated:

> The adverse environmental impacts associated with these transportation modes are not as significant as for pipelines, railroads, etc., both because no permanent facilities are required and because the transportation vehicles cannot carry into the country large numbers of individuals (U.S. Senate 1979).

The type of snowmobile use also changed, from a utilitarian form of access for the traditional activities discussed in ANILCA, such as hunting the trapping, to a new and popular recreational activity in and of itself. Snowmobile manufacturers began producing more reliable, higher-performance vehicles that could travel farther into the backcountry and up much steeper slopes. The level of use in Denali rapidly increased, paralleling a dramatic rise in snowmobile sales and use throughout Alaska. During the past several years, these changes resulted in numerous incursions into the old park. Concern about new pressures on park resources increased with the publication of a newsletter article (Gauna 1998) urging snowmobile users to travel throughout the former Mount McKinley National Park area.

Temporary closure and legal challenge

The National Park Service (NPS) conducted hearings at several locations in Alaska during November 1998 to enact a temporary closure effective February 3, 1999. This closed the former Mount McKinley National Park area to snowmobiles for traditional activities, with the exception of two corridors that were to be used for further information-gathering.

The temporary closure was based on the potential threats of snowmobile use to biological resources, threats to intangible values such as solitude and natural sounds, and potential for user conflicts. NPS emphasized that 95% of south-central Alaska was open to snowmobiles, including the remaining 4 million acres, or two-thirds, of Denali National Park and Preserve. However, because of the nationwide regulation prohibiting snowmobile use in national park units except as specifically authorized by special regulation, the remainder of Denali was open for snowmobile use for traditional activities as stated in ANILCA. The park emphasized that the temporary closure did not affect the remainder of the park and did not set a precedent since snowmobile use for both traditional and other activities would be addressed in a backcountry management plan.

The Alaska State Snowmobile Association, as plaintiffs, and the Wilderness Society, as defendant-interveners, presented various legal challenges to the temporary closure in Federal District Court. The Alaska State Snowmobile Association contended that NPS had violated the mandated snowmobile access expressly provided for in Section 1110(a) of ANILCA, had failed to consider less-restrictive alternatives, and had failed to complete an environmental assessment and provide the adequate public participation required by the National Environmental Policy Act. The Wilderness Society contended that the agency failed to evaluate the effects of the temporary closure in an environmental assessment and had violated the Wilderness Act by allowing snowmobile use in the two corridors left open by the temporary closure (NPS 1999a).

On November 18, 1999, the court voided the temporary closure because NPS had failed to define "traditional activity." NPS followed this decision by continuing work on proposed regulations to define the term and effect a permanent closure of the old park to snowmobile use.

Permanent closure and legal challenge

On November 12, 1999, just before the court ruling, NPS published proposed regulations to define "traditional activity" and permanently close the old park to snowmobiles. Public comment on the proposed regulations closed on January 25, 2000. The regulations were finalized and published in the Federal Register in June 2000, resulting in closure of the old park to snowmobiles beginning in the winter of 2000-2001.

The term "traditional activity" was defined in the new regulations as "involving the consumptive use of one or more natural resources of the Old Park such as hunting, trapping, fishing, berry picking or similar activities" (36 CFR 13.63(h)(1)). Other major components of the permanent closure included the NPS case for proactive management, interpreting and applying laws and policies, and public response. Intangible values were emphasized as with the temporary closure, and the agency argued that research on effects of snowmobile use in other similar areas was relevant.

Two important concepts emerged from analysis of relevant case law. First, in meeting its responsibilities under the Organic Act, NPS need not wait for actual damage to occur before acting *(Wilkins v. Dept. of Interior, 1993; New Mexico State Game Commission v. Udall, 1969).* Second, the agency is expected to allocate limited recreational resources among users (*Bicycle Trails Council of Marin, 1996; Wilderness Public Rights Fund v. Kleppe, 1979;* Bader 1999). The concept of proactive management, or not waiting for damage to occur before acting, is paralleled in the "would be detrimental" phrase in ANILCA. NPS emphasized that a plain reading of this phrase meant acting in advance of proven resource damage was not only appropriate—it was required.

NPS outlined the requirements of the enabling legislation for Denali and demonstrated how this called for a high standard of care. The "unimpaired" mandate in the

Organic Act was emphasized, along with the importance of intangible values as defined in NPS management policies. While site-specific resource information was limited at the time the permanent closure was initiated, the agency held that because of the high standard of care expected for Denali, studies from other similar areas proved the need to exercise caution in allowing any new types of uses in the old park.

NPS cited the Organic Act of 1916 (39 Stat. 535) along with the park's enabling legislation as among the statutory authorities for the permanent closure. The Organic Act grants the Secretary of the Interior the authority to implement "rules and regulations as he may deem necessary or proper for the use and management of the parks…under the jurisdiction of the National Park Service" (16 U.S. Code 3).

The environmental assessment for the permanent closure also stated that the 1978 amendments to the Organic Act (in the Redwood National Park Expansion Act) expressly articulated the role of the National Park System in an effort to ensure ecosystem protection:

> The authorization of activities shall be construed and the protection, management, and administration of these areas shall be conducted in light of the high public value and integrity of the National Park System and shall not be exercised in derogation of the values and purposes for which these various areas have been established, except as may have been or shall be directly and specifically provided for by Congress (16 U.S. Code 1-al.).

NPS management policies were referenced in the permanent closure. These policies interpret laws and regulations and guide decision-making within park units. They direct the agency to protect both tangible and intangible resource values, the latter of which include qualities such as natural sounds, solitude, space, and scenery. The management policies also interpret the "unimpaired" mandate of the Organic Act, clarifying that both tangible and intangible resources and values may be impaired, and that it is agency policy to treat potential impairments in the same way as known impairments (NPS 2000).

In the portion of the park closed to snowmobiles, natural sounds and solitude were identified among the primary values being protected. The agency made a case for proactive management, arguing that existing information was adequate to document a threat to resource values.

Public comments on the proposed permanent closure received during the winter of 1999-2000 showed overwhelming support. Of the 6,039 public comments received, 96% were in favor of the permanent closure. Of comments received from Alaskans, 92% were in favor. This may have reduced the potential for any legislative threats to the closure.

However, in August 2000 the Alaska State Snowmobile Association, the International Snowmobile Manufacturers Association, and three individuals filed a lawsuit in U.S. District Court in Alaska challenging the closure on three main points:

1. NPS improperly interpreted ANILCA in defining "traditional activities" that did not include sightseeing, photography, camping, or picnicking;
2. The agency improperly concluded that any snowmobile use in the old park would be detrimental; and
3. The agency failed to comply with the National Environmental Policy Act in not looking at the potential impacts of the decision to close the old park and by not analyzing the impacts of the traditional activities definition on other parks in Alaska.

The snowmobile groups dropped the lawsuit in late May 2001 without prejudice so that they would retain the option of filing it again later. Their hope in the interim is to pursue a legislative proposal with Congress.

Future challenges: setting limits in a seemingly limitless landscape

NPS faces the future challenge of determining visitor capacity for a wide variety of uses in the park additions, including snowmobile use for both traditional and other (recreational) activities. This will require new methods for implementing the agency's visitor experience and resource protection program. A broad definition of resource values—to include intangible values—will continue to be essential. The park must also anticipate continued rapid advances in technology.

The park has significantly expanded research and monitoring related to snowmobile use since the temporary closure was instituted in February 1999. The planning process relies upon all available scientific information, but scientific studies cannot independently recommend specific limits on recreational and other park uses. These limits must be set based on visitor experience and on accounting for all park values, including intangible values. The environmental assessment on closure of the former Mount McKinley National Park to snowmobile use (NPS 1999a) established the importance of solitude and natural sounds to the overall resource values of the park. The backcountry management plan will expand upon this discussion, with the overall goals of protecting resources and continuing to provide for a range of visitor opportunities. Among these opportunities are activities in which the natural and cultural environment of the park are the focus of the experience. These goals will guide decisions on appropriate levels and types of access, including recreational snowmobile use, in the park additions.

Conclusions

Among the lessons learned during the snowmobile case is that losing in court is not necessarily a problem if we win in the court of public opinion. Public understanding and support for challenging management actions is critical. We must continue to do everything possible to acquire new resource information.

Statutes such as the Organic Act, the Wilderness Act, and the park's enabling legislation set the vision for protecting Denali National Park and Preserve. Protecting intangible values such as aesthetics, natural sounds, and opportunities for solitude and inspiration is a critical part of realizing this vision. The park will continue to bring these values into the discussions of appropriate levels and types of use while completing the backcountry management plan that determines the future of the internationally significant Denali wilderness.

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31 Minimum group sizes: allowing public access and increasing safety

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Background

The Moraine Lake area of Banff National Park receives high levels of human use every year, from a variety of activity groups. Backcountry human use over the summer months in the Moraine Lake area includes hiking, mountain biking, climbing and scrambling, horse use, as well as an assortment of day uses.

In addition to human use, the Moraine Lake area is a part of the home range of a grizzly bear. Due to the high numbers of visitors in the area, the bear has become habituated to people, vehicles, and facilities. The result has been distinct bold behavior shown by the grizzly bear (e.g., following hikers, initiating bluff charges), thus creating conflict between human use and bear use.

Interim operational protocols for the Moraine Lake area have been identified to manage bears and people. In 1997 and 1998, the area was closed for the majority of the summer season in response to the Moraine Lake grizzly. In 1999, in an attempt to allow human use in the area while at the same time reducing the potential for bear–human conflict, an interim management protocol, known as "restricted access," was implemented. This protocol, which has legal force, means that while the grizzly bear is in the area:

- Hikers are required to travel in a tight group of six or more on backcountry trails;
- Mountain bikers are not permitted on the designated mountain biking trail; and
- Horse users must travel in a group of two or more.

Restricted access compliance was evaluated in 1999 through warden patrols and the administration of a trail-user survey. While public support for the initiative was high, group compliance with the strategy was found to be relatively low (54%). It was also found that specific groups were not as compliant as others were.

After the test run of restricted access in 1999, the park executive decided to continue with the approach in 2000, with an overall goal of 80% compliance with the strategy. Three components of the strategy require complete evaluation before a determination on the success of restricted access can be made: (1) ecological effects (effects on wildlife); (2) social effects (effects on users of the area); and (3) operational effects (effects on resources, staff, costs). In 2000, the focus was on evaluating the social effects of restricted access.

Restricted access implementation 2000

After several earlier sightings of the Moraine Lake grizzly, restricted access was invoked on August 2, 2000. After the subsequent two weeks had elapsed without a sighting of the bear, the restricted access order was lifted on August 16. Restricted access was then reinstated on August 24, due to another bear–human encounter. Restricted access stayed in place until September 20, 2000, when, after a number of encounters with the Moraine Lake grizzly, the Moraine Lake backcountry area was closed to all users.

From **Crossing Boundaries in Park Management: Proceedings of the 11th Conference on Research and Resource Management in Parks and on Public Lands,** edited by David Harmon (Hancock, Michigan: The George Wright Society, 2001).

Methods

Throughout the summer, a questionnaire was administered to the users of the Moraine Lake area who had been affected by both closures and restricted access in the past. A random sampling technique (next-to-pass) was used, with an over-sampling of the user population during restricted access. In total, 653 surveys were completed, 393 prior to restricted access and 260 during the restricted-access period. The results presented are considered accurate within 5.7% 19 times out of 20. As a result of the methods used, and rigor applied through the survey administration, we are comfortable in stating that the results accurately depict the opinions of the hikers in the area.

User support

Overall, users of the Moraine Lake area stated that they were supportive of the restricted access strategy. Throughout the hiking season, users were asked to state their level of support for the strategy, on a scale of one to five. Depicted in Figure 31.1 are the stated levels of support for the strategy.

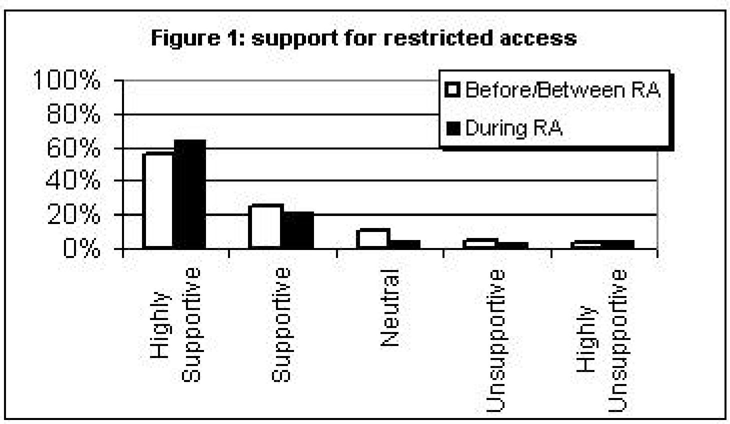

Figure 31.1. Support for restricted access.

The results, as presented in Figure 31.1, indicate both a higher level of support for restricted access during the time over which it was implemented and also a higher level of dissatisfaction with the strategy. When restricted access is in place, the public has the opportunity to access the area, while the alternative scenarios in the past have resulted in no access; therefore, this is a better situation, thus higher levels of support. Dissatisfaction may be attributed to the inability to access the area as they wish to, in small groups for example. The difference in results between the time when restricted access was in effect and the time when the area was simply open illustrates the difference between theoretical and actual support. As a general rule, people's opinions change when they answer actual versus theoretical questions. It is interesting that people's opinions of restricted access indicate a greater level of support when the strategy affected them directly.

Effect on experiences

Because the requirements of restricted access significantly change the way people travel, we were interested in knowing how that affected people's experiences. The results indicated that 60% of user users felt that their experience was not affected by restricted access. Approximately 24% said that it had a positive effect (by meeting new people with similar interests), and 16% indicated that the effect was negative.

Compliance

The identified compliance target against which the success of restricted access was to be measured is 80% of users traveling out of the area. Presented in Figure 31.2 are the resultant effects of having a uniformed park presence at the trailheads, in addition to the general compliance as a result of the communication tools in place. Through conversations with the users of the area, compliance of hikers going into the restricted access area increased by 23% and the overall compliance by 12%.

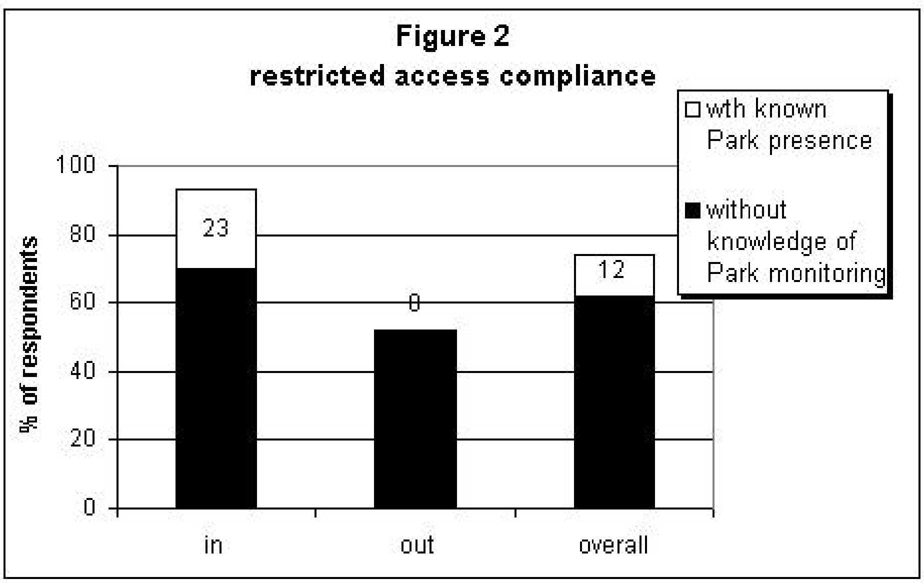

Figure 31.2. Restricted access compliance.

Changes in compliance as restricted access was reapplied

As a result of observed activity by the grizzly in the area, the restricted access order was lifted on August 16, 2000, and reapplied on August 24. During that time, some serious and high-profile human–grizzly encounters occurred in and around Canmore and Kananaskis Country, Alberta. Those encounters may have affected the level of compliance with restricted access, due to the elevated media profile around the other mentioned incidents. Presented in Figure 31.3 are the compliance levels based on the two applications of restricted access. It is fairly evident that the longer restricted access was in place, the greater the level of compliance. However, the crux of the issue is the fact that through all of our efforts, compliance for groups traveling out of the restricted access areas was below the established target.

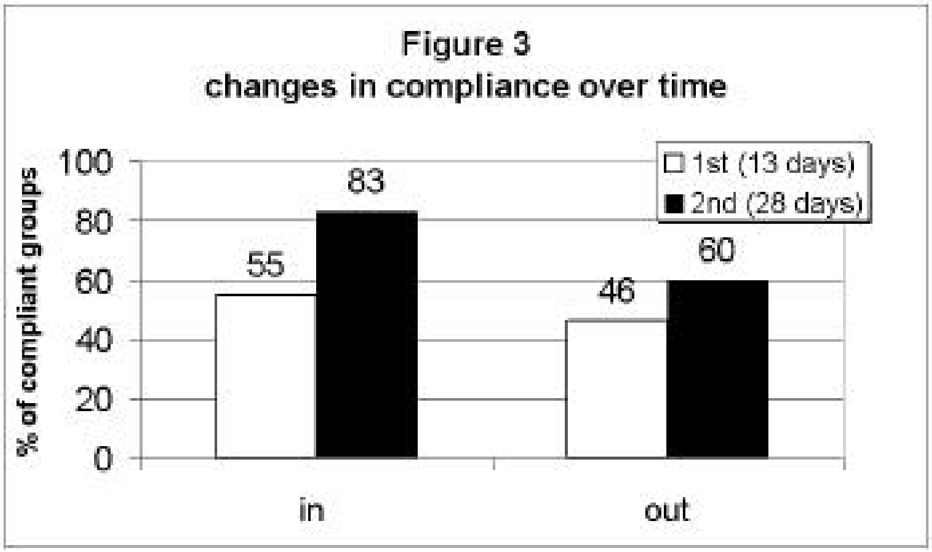

Figure 31.3. Changes in compliance over time.

Volume of use and group size

As could be expected, restricted access had a marked difference on both the numbers of people entering the trails around the Moraine Lake area, and the group size in which they traveled.

The size of the groups entering the area changed significantly between the periods of restricted access and non-restricted access. As depicted in Figure 31.4, the average group size of survey respondents during the second application of restricted access was more than the requested six people per group.

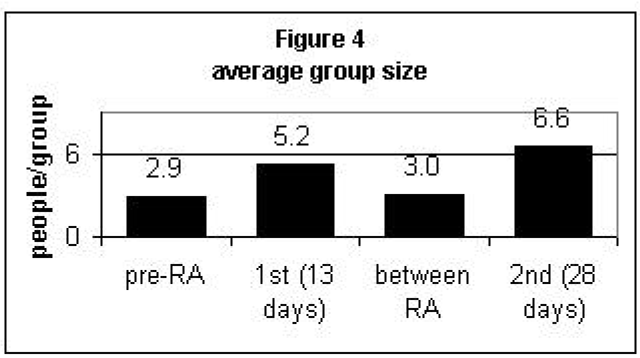

Figure 31.4. Average group size.

Discussion

Restricted access represents a "learning curve" for both the public and Parks Canada. It is encouraging that compliance with the strategy increased as it was applied throughout the summer. This may be evidence to suggest that the public may be slowly becoming more accepting of restricted access, and willing to modify their patterns of use to ensure that the area remains open.

The evaluation of the social components of restricted access focused beyond compliance. Even if compliance were very high, there needs to be a general societal acceptance for altering behaviors.

- The users are generally very supportive (81% of respondents) of the idea of restricted access. The users were more supportive (86%) of the restricted access protocol when it was in place and affected their experiences.
- The majority of visitors to the area (60%) did not have their experience affected by restricted access; 24% said that it affected them in a positive way.
- There is evidence to suggest that restricted access increases people's bear awareness and safety precautions.
- Average group size is significantly increased during restricted access, thereby (it is hoped) reducing the chances of an encounter with the grizzly.
- The volume of use on the trails (including sensitive alpine areas of the Larch and Paradise valleys) dropped during restricted access. Although this is not a goal of restricted access but rather a result, it may contribute to fewer human–bear encounters on the trail.
- Fifty-two percent of the users of the area were aware of the restricted-access protocol prior to reaching the trailhead. Approximately 48% of the 2000 survey respondents indicated that they found out about the restricted-access protocol at the trailhead, compared with approximately 95% in the 1999 survey.
- Overall, there were fewer sightings of the grizzly bear during the summer of 2000 (Morrison 2000). We are unable to directly link this to the restricted-access protocol.

The fact that restricted access was implemented without a decrease in the proportion of visitors satisfied with their experience is very promising. Public support for restricted access, both before and during the time it is applied, continues to be very high. Bear safety precautions, such as people increasing their group size and carrying bear spray, increased during periods of restricted access.

Challenges

One of the greatest challenges that was identified for the communications during the summer was the inability to present the overall goal of grizzly bear management for the area. It was very difficult to communicate the big picture, in terms of bears and people, for the Moraine Lake area. Another significant challenge in the general context is what messages should be presented to the public with relationship to habituated bears. A level of habituation has been accepted for the Moraine Lake grizzly, but what will that mean for other habituated grizzlies throughout the park? These issues are not specific to the restricted-access protocol; however, they did make effective communication—that which is in context with an overall vision—very difficult.

Obviously for restricted access to be truly effective, compliance rates must continue to increase. This is directly linked with the ability to effectively communicate our message. The greatest communication challenge is that the public's overall level of understanding of the reasoning behind restricted access is still unclear. Many comments captured through the survey identified a general lack of understanding of the rationale behind the restricted-access protocol.

Future application of restricted access

Based on the results presented, the park's executive must decided if the restricted-access approach, as a means to allow public access with some level of public safety, is a good one for the Moraine Lake area. They must understand the many challenges and benefits, and seriously consider this prior to future application. The question remains as to whether the protocol will be implemented as it was during summer 2000, or if we can modify the protocols to increase the level of success. The decision for the future application of the restricted-access protocol will have to consider legal liability to the Parks Canada agency.

Although this report has focused primarily on the social effects of restricted access, the park needs to better understand the effects of this type of strategy on the grizzly bear. If we are to gain knowledge on the wider application of this approach, we need to evaluate it beyond the social effects and link it to the ecological effects. One of the primary knowledge gains as a result of the study is that we can alter the way people visit an area, while simultaneously maintaining quality experiences. What we need to determine is, can we continue to allow the current protocol—and continue to support the resident bear's needs?

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32 Mountain lion–human interactions on the Colorado Plateau: the effects of human use areas on mountain lion movements, behavior, and activity patterns

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Mountain lions are the sole remaining large predator in the Southwest (aside from reintroduction efforts for the Mexican gray wolf in the eastern portion of the state) and, as such, play a unique role in parks' natural systems. They are the ecoregion's only remaining natural predators of adult mule deer, elk, desert bighorn sheep, and, recently, javelina. This project has begun to document movement patterns of mountain lions associated in and adjacent to areas of human use at Grand Canyon National Park.

Although seldom seen by visitors, simply the presence of large carnivores contributes to the richness of visitor experience. However, recent increase in the frequency of attacks on humans by mountain lions has led to human safety concerns in areas where people concentrate in mountain lion habitat. Changes in the distribution and abundance of prey, and in mountain lion hunting behavior, as well as movement of humans into areas traditionally occupied by mountain lions, have been advanced as factors contributing to increased human–mountain lion incidents.

The increase in the frequency of mountain lions attacking humans has heightened concerns of managers in areas where mountain lions and people coexist. Although mountain lions are present throughout Grand Canyon National Park and the Colorado Plateau, little is known of how they use the region's parks and monuments. With increased pressure from hunting, poaching, and habitat reduction, parks and monuments are believed to be not only refugia for these large carnivores, but also to serve as reservoirs for their populations as they disperse into these areas of high pressure. Knowing how and when mountain lions use these parks and park habitat, especially those areas frequented by park visitors, may provide the information needed to reduce the potential for mountain lion–human interactions.

Obtaining information on wild animal populations has been a long-standing logistical problem. However, the ability to detect and analyze animal sign in the wild through non-invasive techniques is becoming an integral part of wildlife research and management. Particularly with carnivores, which are generally secretive and costly to capture and study, DNA samples from field-collected hair, tissue, and feces can yield insights into the ecology of difficult-to-study creatures such as mountain lions. A three-year study of mountain lions within Grand Canyon National Park is proving that DNA sampling and analysis of genotypes is an effective, low-cost method for detecting and identifying individual mountain lions, kinship, and minimum population estimates. This study is beginning to provide a framework for other parks, particularly those on the Colorado Plateau (many of which have little or no budget to collect this information) with similar habitat types, to obtain information regarding their mountain lion populations in order to preserve an integral component of the ecosystem while providing for visitor safety. Information already gathered at Grand Canyon is providing insight into mountain lion populations, distribution, and kinship.

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Although numerous techniques have been proposed for the enumeration of cougar populations, few have been simultaneously applied and rigorously evaluated for their efficacy and accuracy. The study being conducted at Grand Canyon is analyzing a variety of methodologies, including ground-based track counts in winter and summer, and mark-recapture methods combined with scent station visitation. The latter is a non-invasive technique that captures a DNA sample from hair, allowing for analysis of age, sex, kinship, and animal identification.

National parks, because they offer security from hunting and generally stable habitats, tend to attract ungulates and the predators that feed on them. Habituation of deer and elk to humans and their structures often results in them living among humans and attracting predators to these areas. Increasing elk numbers on the South Rim of Grand Canyon may have contributed to a shift in dispersion of mule deer and elk toward areas with higher human densities. This past year, we have frequently documented sites where mountain lions have killed deer, elk, and javelina on the North and South rims of the park, including the developed zones adjacent to campgrounds, schools, and residential dwellings. In addition, mitochondria and nucleic DNA analysis is starting to provide information on lion home ranges and kinship. In one year of field data collection, we have identified sixteen individuals and several kinships among these individuals. The next two years will focus on estimating home ranges.

Knowing the spatial and temporal patterns of mountain lion use in the park and focusing on areas of high human density are providing the basis for risk assessment. For example, it is possible mountain lions use developed areas only at night and retreat to secluded areas during the day when humans are most active. There appears to be an influence on lion behavior resulting from loose and feral pets and habituated and abnormal concentrations of large prey species in and around the developed zone. Further, manipulation of vegetation in and around areas of concern may directly (through loss of hunting habitat) or indirectly (through changes in distribution of deer and elk) reduce the likelihood of human–mountain lion interactions.

Understanding the adaptability of lions in the presence of humans—i.e., how and where lions spend their time, and to what extent, how, and where do lions interact with humans—has been identified by researchers as a high priority for research. Information being obtained from this research will have direct applicability to development of management alternatives. The comparative nature of this study will allow for refinement of alternatives that will be transferable to other areas throughout the range of the mountain lion, particularly on the Colorado Plateau.

The objectives of this study are to:

- Continue to document movement patterns of mountain lions, focusing on areas of high human density in Grand Canyon (river and rims) and throughout the Colorado Plateau at those parks that are interested in obtaining this information (interest has been expressed by Mesa Verde National Park and the Flagstaff area park units); and
- Relate temporal and spatial use patterns of mountain lions to areas of the parks emphasizing those areas that receive heavy human use.

In order to:

- Maintain a naturally functioning and viable population of lions;
- Ensure safety of park visitors and staff; and
- Address education of park visitors and staff on mountain lion biology in order to minimize the risk of being attacked.

Funding in 2000 allowed for the preliminary collection of baseline data regarding DNA, compilation of prey-base information, and establishment of track and vegetation transects, mainly in concentrated areas of the South and North rims. The continuation and expansion of this research, not only at Grand Canyon but at other parks on the Colorado Plateau, will provide a larger sample size, thereby increasing the reliability of results. Concurrent studies would also allow for investigation of how mountain lions respond to varying human population densities and to levels of developments in different geographical locations.

We are just beginning to collect scientific information that allows us to evaluate human risk from observed lion behaviors. This research will allow the National Park Service to refine its management strategies and recommendations for dealing with human–lion encounters in a proactive manner.

Because lions are predators and are fully capable of killing a human, our inclination is to assume a hazardous or lethal possibility in any lion behaviors that we do not understand or are unable to interpret. Therefore, we should attempt to manage those conditions which are conducive to lion encounters and could escalate into human injury. Data from this research will enable the Park Service to establish scientifically based recommendations for management that will help ensure visitor safety and resource protection.

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33 Crossing international boundaries in park management—a survey of transboundary cooperation

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Introduction

How are the boundaries in park management to be crossed when those boundaries are not only geographical and political, but also international—when in addition to all the difficulties of transboundary cooperation, issues of national security and sovereignty also enter into the picture? Contrary to reasonable expectations, surprising degrees of transboundary cooperation are occurring between internationally adjoining protected areas around the world. As a continuation of research introduced at the 1999 George Wright Society Conference, this paper presents additional results from an international survey sent to the managers of all the adjoining protected areas around the world. The findings reveal which factors are currently encouraging or inhibiting transboundary cooperation in conservation, and that seemingly insurmountable barriers are being overcome. The case of North American adjoining protected areas, where transboundary cooperation is stronger than in the world at large, tends to confirm the global findings. Evidence of cooperation in park management across international boundaries provides reason for hopefulness that boundaries on a lesser scale, while creating obstacles, may be crossed as well.

Internationally adjoining protected areas—then and now

The paper included in the proceedings of the 1999 GWS Conference introduced a research project on international transboundary cooperation in conservation (Zbicz 1999a). This project was designed around three goals.

1. Identification of all the places in the world where protected areas meet across international boundaries, as examples of internationally divided ecosystems.
2. Design of a framework for the study of transboundary cooperation for conservation, incorporating increasing levels of transboundary cooperation and description of its current state between these internationally adjoining protected areas.
3. Identification of those factors which correlate with increasing levels of transboundary cooperation between internationally adjoining protected areas.

Findings related to the first two goals were presented in the 1999 paper.

In 1997, the author identified 136 complexes of internationally adjoining protected areas, containing 488 individual protected areas in 98 different countries (Zbicz and Green 1997). Twenty-seven of these clusters involved three different countries. An additional 69 complexes with an established protected area on one side of the border and a proposed one on the other side were also identified and listed as proposed complexes. Since developments in transboundary conservation are proceeding at such a rapid pace, an update of this list was recently undertaken. In only four years, the number of internationally adjoining protected area complexes has increased to 169 complexes involving 650 individual protected areas. The complexes involve 113 different countries, with 31 of the complexes involving three

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countries, and one in Europe including four (Zbicz 2001). Much of the increase is attributable to the fact that 29 of the 1997 proposed complexes have now met the criteria to be included on the established list. Interestingly though, almost as many new sites have been added to the proposed list, suggesting that the numbers should keep increasing for several years to come. Table 33.1 shows the increase in complexes broken down by region.

	PACs, 1988	*PACs, 1997*	*PAs, 1997*	*PACs, 2001*	*PAs, 2001*	*Three-nation PACS, 2001*
North America	5	8	42	10	47	0
Central & South America	7	25	93	29	120	6
Europe	20	44	154	64	227	8
Africa	20	33	123	36	151	12
Asia	7	26	76	30	105	5
Total	*59*	*136*	*488*	*169*	*650*	*31*

Table 33.1. Number of internationally adjoining protected area complexes (PACs) and individual protected areas (PAs) by region, 1988-2001.

Transboundary cooperation in conservation

The second phase of the research entailed sending a survey to the managers of these adjoining protected areas, and designing and testing a framework for examining transboundary cooperation in conservation. This resulted in identification of six increasing levels of transboundary cooperation between pairs of adjoining protected areas, with each level including the positive attributes of the lower levels, suggesting that transboundary cooperation proceeds through stages. The six levels are:

- ***Level 0:*** *No cooperation.*
- ***Level 1:*** *Communication*—Information-sharing.
- ***Level 2:*** *Consultation*—Notification of actions.
- ***Level 3:*** *Collaboration*—Active collaboration on several activities and frequent communication and meetings.
- ***Level 4:*** *Coordination of planning*—Planning for the two protected areas as a single ecological unit, sometimes even planning jointly.
- ***Level 5:*** *Full cooperation*—Fully integrated, ecosystem-based planning, with common goals and joint decision-making by a transboundary committee, sometimes even involving joint management.

Identification of the criteria required for each level of transboundary cooperation permitted using the information from the survey responses to classify each pair or dyad of adjoining protected areas at a particular level of cooperation. Degree of cooperation was nicely distributed among the dyads in the study. Although 18% of them show no cooperation, 82% do show that they are cooperating to some degree (Zbicz 1999a). The largest percentage of these, however—39% of the total—are only cooperating at Level 1 (communication and information-sharing), leaving much room for improvement.

Once the level of cooperation was determined for each pair of adjoining protected areas, then various factors could be tested to see if they inhibit or encourage this cooperation. Fifty-one variables were created from theories of international cooperation and from other studies on transboundary conservation (Hamilton 1996). Simple pairwise correlations were then run with the level of cooperation, and the variables were ranked by their r-values. A Monte Carlo randomization procedure for this number of variables and cases revealed that r-value above .298 could be considered statistically significant at the conservative .01 level. This process has been described in detail elsewhere (Zbicz 1999b). While correlational analysis cannot determine direction of causation, it can show the strength of the relationship between variables. Twenty-five of the variables proved to be significant even at this quite conservative level, while many others would have been included at the .05 level.

Variables and factors

While many of the variables proved to correlate with cooperation, in all probability few of them are operating in isolation. Some of the more interesting observations are the relationships between the variables themselves and how certain groups of variables tend to co-exist. In order to examine this phenomenon, a factor analysis was conducted on sixteen of the significant variables with the highest r-values. This analysis revealed four statistical factors or clusters of variables which were named the *idea factor, the communication technology factor, the leadership factor,* and *the personal contact factor.* The variables loading on each of these factors can be seen in the table below. When combined in a multiple regression model, these four factors are able to explain 59% of the variance in cooperation between pairs of adjoining protected areas (Zbicz 1999b).

Of all the 51 variables, the one with the highest r-value (.538) in its correlation with level of cooperation was "the number of protected areas in a dyad saying that transfrontier cooperation is important to management of that protected area." In fact, 88% of the protected areas responding to the survey said that transfrontier cooperation was important or very important to protected area management. Before adjoining protected areas cooperate, they must share the vision and perceive a need for cooperation. Several other variables also loaded on this factor, as seen in Table 33.2. Valuing ecosystem-based management and biodiversity conservation provide the justification for transfrontier cooperation, but interestingly, valuing the rights of all stakeholders and future generations are also important components of this factor.

The other three factors all illustrate that, like all cooperation, the transboundary version is about human relationships. The *leadership factor* suggests that personal, individual leadership is fundamental, and that the type of leadership required often involves experience with ecosystem-based management. The two other factors both relate to communication. Of any of the four factors, *personal contact* correlates the strongest with level of cooperation, and appears to be especially important at lower levels of cooperation where establishing trust and building relationships are paramount. On the other hand, *communication technology* appears to be more important as higher levels of cooperation are reached and frequent interactions are required. The variable "ability of the staff of the two protected areas to meet face-to-face" has the highest r-value of any variable at .53, yet surprisingly does not correlate significantly with the variable "whether or not the two protected areas are managed from on-site." Somehow, transboundary cooperation occurs even without on-site management as staff go to great lengths to find other ways to meet with their counterparts. Other access variables, such as the existence of a road between the protected areas, travel time between them, and whether or not they speak the same language did not correlate significantly with cooperation.

Variable	R-value	Loading
The idea factor		
No. of PAs in dyad saying biodiversity conservation important	.427*	.878
No. of PAs in dyad saying including all stakeholders important	.443	.873
No. of PAs saying ecosystem-based management important	.384	.867
No. of PAs in dyad saying conserving resources for future generations important	.296	.789
No. of PAs in dyad saying transfrontier cooperation would improve management of that protected area	.320	.729
No. of PAs in dyad saying ecosystem-based management a benefit of transfrontier cooperation	.344	.665
No. of PAs in dyad saying transfrontier cooperation important	.538	.634
The communication technology factor		
No. of PAs in dyad saying fax available	.424	.854
No. of PAs in dyad saying phone available	.398	.836
No. of PAs in dyad with mail available	.327	.681
No. of PAs saying transboundary communication is difficult	-.414	.640
The leadership factor		
No. of PAs in dyad with an NGO promoting transfrontier cooperation	.399	.755
No. of PA s in dyad with an individual promoting transfrontier cooperation	.423	.750
No. of PAs with staff experienced in ecosystem-based management	.453	.447
The personal contact factor		
No. of PAs in dyad managed from on-site headquarters	.352	.712
PA staff can meet face-to-face	.530	.639
No. of PAs saying transboundary communication is difficult	-.414	.480

* R-values above .298 considered significant at the .01 level.

Table 33.2. Variables loading on four factors.

One factor expected to affect cooperation was how much opposition the protected areas were experiencing, with several survey questions addressing this. Two questions relating to the "number of protected areas in a dyad experiencing opposition to conservation and experiencing opposition to transfrontier cooperation" both had relatively low r-values (.229 and .032 respectively), indicating that even if a relationship does exist with cooperation, it is weak. An interesting observation, however, was the fact that the signs of both r-values were positive, the opposite of expected. If any correlation does exist, this finding would indicate that the more cooperation taking place, the more opposition is likely to be present. In reality, over 75% of the dyads at Levels 3-5 are experiencing opposition to conservation.

International transboundary cooperation in North America

North America contains 8 complexes of adjoining protected areas in only three countries, with 42 individual protected areas and 16 different dyads. Surveys were received from all of the dyads in North America, and while numbering too few for statistical conclusions, they do permit some observations and comparisons about the distributions. Compared with the global percentages, more high-level cooperation is occurring in North America, with 9 of the 16 dyads cooperating at Levels 4 and 5. An examination of the variables that were significant globally also discloses some differences for North America consistent with higher cooperation. A greater percentage of dyads in North America have both sides saying that transfrontier cooperation, biodiversity conservation, and inclusion of all stakeholders is important. A greater percentage of the dyads in North America also have an individual leader promoting transfrontier cooperation. While 46% of dyads globally know of such an individual, 81% in North America (13 dyads) have such a leader (Figure 33.1). A greater percentage also have non-governmental organizations (NGOs) on both sides of the border promoting transboundary cooperation (Figure 33.2).

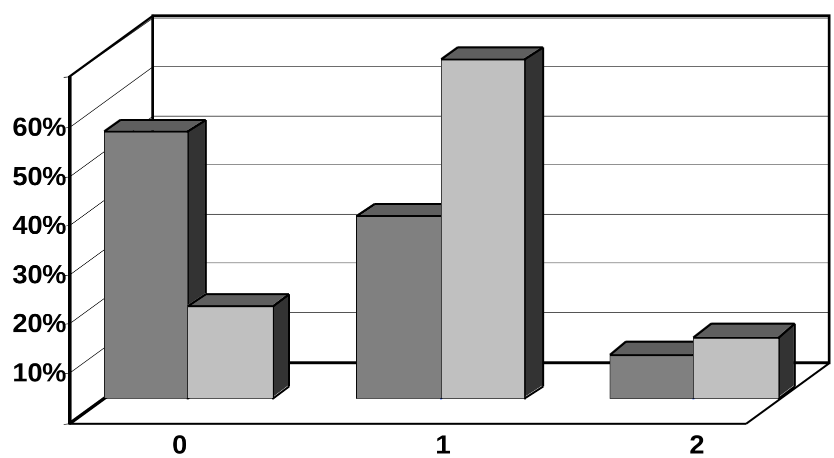

Figure 33.1. Number of protected areas in dyad that know of an individual promoting transfrontier cooperation.

For the *personal contact* factor, the percentage of dyads managed from on-site is very similar for North America and the world. However, a greater percentage of the North American dyads have the ability to meet face-to-face, in spite of a lack of on-site management. All except for one dyad on the continent say that communication is not difficult, and even that one says that it is only moderately difficult. As would be expected, the availability of communication technology is better for North America than globally, thus making frequent communication easier and better enabling higher levels of cooperation.

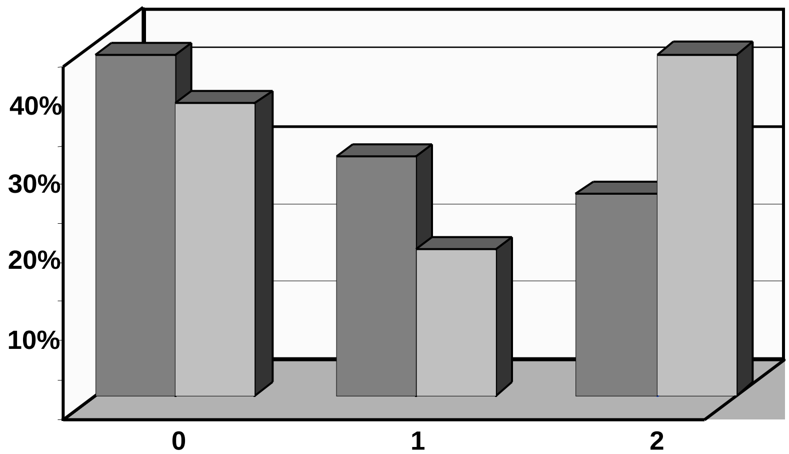

Figure 33.2. Number of protected areas in dyad with an NGO promoting transfrontier cooperation.

Comparing the presence of opposition is also informative. Eight of the dyads in North America have opposition to conservation (three of which experience opposition on both sides of the border), similar to the percentage globally (about 50%). However, six dyads in North America (37%) have opposition to transfrontier cooperation, compared with only 11% globally. It would appear that a greater percentage of adjoining protected areas in North America are facing political opposition to transboundary cooperation than are those around the world. As noted earlier on the global level, though, this may not necessarily prevent cooperation. As true for the study as a whole, opposition appears to co-exist with higher levels of cooperation.

Conclusion

So, what general observations about transboundary cooperation in conservation can be gleaned from this analysis? Although some of the variables tested do indeed correlate strongly with the level of transboundary cooperation, no truly necessary conditions emerged in the study overall. One overriding message is hopeful. Although too many obstacles may overwhelm transboundary cooperation, almost every single obstacle is being overcome in some situation around the world. Transboundary conservation is indeed occurring between internationally adjoining protected areas, even if much of it is still at the lowest levels. The need for increased cooperation remains.

These findings, both globally and for North America, also suggest that some factors are quite important to transboundary cooperation in conservation. Firstly, a shared vision of the need for transboundary conservation must be present to create the desire to cooperate. As with all cooperation, in spite of the desire for high-tech solutions, transboundary conservation is about human relationships. Frequently complicated and often dependent upon individual personalities, the process often moves much more slowly than conservation would prefer (and sometimes too slowly to take the necessary steps to enable species to survive). Transboundary cooperation can be cultivated and nurtured, but not forced. Individual leadership is critical to the process. Likewise, enabling and fostering communication and face-to-face meetings is essential. Perhaps most hopeful for this conference is the finding that if transboundary cooperation can occur at the international level where the complexities are the greatest, then hope should exist for even better results in situations where cooperation across boundaries of other types is required.

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34 International transboundary cooperation: some best practice guidelines

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The rationale for transboundary protected areas

Special consideration should be given by governments (national or sub-national) to establishing border-contiguous protected areas, and to engaging in management of abutting protected areas in the following situations:

- Where boundaries are located in shared water bodies such as rivers or lakes, and perhaps even for shared underground aquifers, e.g., Rio Grande at Big Bend/Cañon Santa Elena (USA–Mexico).
- Where an important earth feature such as a mountain or a glacier or a coral reef contains national or sub-national boundaries, e.g., Mount Kanchenjungma (India, Nepal, China), Israel-Jordan Coral reef in Red Sea; needed for Mont Blanc, which has no protection, between Italy, France, and Switzerland.
- Where a natural ecological system straddles one or more boundaries and needs to be managed as a single ecological unit in order to preserve essential species, communities, and ecological processes, e.g., ibex in La Vanoise and Gran Paradiso, which move across the Alps in winter–summer ranges from Italy to France.
- Where local communities and indigenous peoples in natural areas are linked across boundaries by shared ethnic or sociocultural characteristics, traditions, and practices, e.g., indigenous native hunting in Kluane (Canada)/Wrangell-St. Elias (USA).
- Where the use or management of shared natural resources is or may become a locus of contention, e.g., oil at the Ecuador/Perú border where, after armed conflict, a truce and a Peace Ecological Reserve was established in the Sierra del Condor.
- Where a boundary dispute involves unresolved claims to land or water, e.g., needed in Kashmir between India and Pakistan where there is fighting over ice and snow.
- Where, after a period of armed conflict, there is a need to rebuild confidence and security for local communities and provide a stable foundation for conservation and sustainable development. Needed in the Demilitarized Zone (DMZ) between North and South Korea, which has become a *de facto* protected area providing valuable crane protection (Anh and McGahey 1992).
- Where there is a need to cooperate against common threats to ecosystems and their integrity, e.g., fire or invasive alien species, with agreements such as that between Quetico Wilderness Park (Canada) and Boundary Waters Wilderness Canoe Area (USA) for fire response.

Such needs should, and sometimes do, impel governments or the agencies themselves to take action and initiate formal agreements of various kinds and stature, or memoranda of understanding. There are now more than 169 abutting pairs or complexes of protected areas worldwide in the World Conservation Monitoring Centre / United Nations Environment Program data files; the potential exists for another 69 (Zbicz, this volume). Zbicz (1999) has characterized the degree of cooperation

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among them and is further elaborating this topic in this present George Wright Society conference session. In some cases sub-national boundaries, as between states, provinces, cantons, or whatever, can also be serious impediments to rational land or water conservation, for each may zealously guard their resource ownership rights. Here too, abutting protected areas and transboundary cooperation (TBC) management are devoutly to be wished. Good examples of such effective TBC are in Hohe Tauern National Park (the states of Salzburg, Tyrol, and Carinthia within Austria) or in Australian Alps National Parks (New South Wales, Victoria, and Australia Capital Territory), involving nine separate units.

The concept and approach can, of course, also be extended to cooperation between different management agencies or authorities even in one state or nation when the boundaries of their jurisdictions abut, and some of the previously mentioned needs exist. Many innovative interagency arrangements have been implemented here in the USA, for example as part of the Northwest Forest Plan (U.S. Forest Service, Bureau of Land Management, National Park Service, U.S. Fish and Wildlife Service, and Department of Defense) described in a paper given at the 1997 GWS Conference (Milestone 1997). A good example from overseas is in the Queensland/Commonwealth collaboration in the Great Barrier Reef Marine Park.

Benefits of TBC

The benefits of TBC have been previously described by me (Hamilton et al. 1995; Hamilton 1998) and are presented in shortened form as Box 34.1. They seem compelling if there are abutting protected areas. An IUCN–The World Conservation Union (IUCN) publication (due out at end of May 2001) emphasizes international tension reduction and peace promotion values, having the title *Parks for Peace: Transboundary Protected Areas for Peace and Cooperation* (Sandwith et al. 2001).

Impediments to TBC

Yet, the path of cooperation in TBC is not always a smooth one. There are impediments to effectiveness, and some of these are presented in Box 34.2.

Guidelines and best practices for TBC

1. There should be made eminently manifest some *unifying theme* or *icon* that promotes common values and a mutual vision. A common logo, such as is used for all three state units (divisions) of Hohe Tauern National Park (a stylized bird) or the representational mountain logo of the Australian Alps, even though each of the park agencies has its own logo for their total state park system. A common name across the border as in the case of Royal Manas National Park (Bhutan) and Manas Sanctuary (India) is effective, or a joint name that appears coupled repeatedly under some larger umbrella, such as Waterton/Glacier International Peace Park or Vosges du Nord/Pfälzerwald Transfrontier Biosphere Reserve (France/Germany). This not only binds the protected area staff but local people on both sides of the border.

2. Good TBC will result in capturing the economic benefits and unifying effects of joint development and production of *common materials for education and information.* These present and interpret the natural and cultural values of the whole area, across the boundary. A common map, brochures, exhibits, and audio-visual material not only present this holistic view, but give economies of joint production. The two-language booklets (French and Italian) produced by Mercantour and Alpi Marittime, such as “Mountains Without Frontiers,” are good examples.

3. A *joint approach* to visitation and tourism can yield beneficial dividends. Costs are reduced for any joint marketing or work with the tourism and travel industry. A shared visitor information center on or close to the boundary has great appeal to visitors and may replace two separate facilities. This has been done for Bavarian Forest National Park (Germany) and Sumava National park (Czech Republic). Botswana and South Africa are working together for appropriate tourism and revenue sharing in Kgalagadi Transfrontier Park. The nine units of the Australian Alps in three jurisdictions have agreed on, and published, common visitor codes for: car-based camping, bushwalking, horse riding, snow camping, river use, and mountain biking.

- A larger contiguous area will better safeguard biodiversity since very large areas are needed to maintain minimum viable populations of many fauna species, particularly large carnivores.
- Where populations of flora or fauna cross a political or administrative boundary, TBC promotes ecosystem or bioregional management.
- Reintroduction or natural recolonization of large-range species is facilitated by TBC.
- Pest species (pathogens, insects) or alien invasives that adversely affect native biodiversity are more easily controlled if joint control is exercised rather than having a source of infection across the boundary.
- For rare plant species needing *ex situ* bank and nursery facilities, one facility for both parks will be cheaper to set up.
- Joint research programs can eliminate duplication, enlarge perspectives and the skills pool, standardize methodologies, and share expensive equipment.
- Wildfires cross boundaries, and better surveillance and management is possible through joint management.
- Poaching and illegal trade across boundaries are better controlled by TBC. Cooperation is needed for effective law enforcement. Joint patrols in border areas become possible.
- Nature-based tourism is enhanced because of a greater attraction for visitors, the possibilities of joint approaches to marketing and tour operator training, and the possibility of agreements on fees, visitor management, etc.
- More cost-effective and compelling education materials can be produced, and joint interpretation is stronger concerning shared natural or cultural resources.
- Joint training of park staff is more cost effective and usually benefits from greater diversity of staff with different experiences.
- TBC improves staff morale and reduces feeling of isolation. Contact with cultural differences enriches both partners.
- TBC makes staff exchanges easier, and staff exchange programs have shown their worth.
- A cross-boundary pool of different expertise is available for problem solving.
- Expenses for infrequently used heavy equipment, aircraft rental for patrols, etc., may be shared.
- TBC in priority actions can carry more weight with authorities in each country.
- The ministry level may feel greater obligation to honor commitments of support when another jurisdiction or another country is involved.
- International donors and assistance agencies are more attracted to an international joint proposal.
- Outside threats (e.g., air pollution, inappropriate development) may be more easily met when there is an international or interstate response.
- Customs and immigration officials are more easily encouraged to cooperate if parks are cooperating.
- Search and rescue is often more efficient and economical.

Box 34.1. Benefits of transboundary protected area cooperation (based on Hamilton et al. 1996).

4. Common nature and culture *interpretation* themes and joint interpretation activities that cross the border are hallmarks of a high degree of cooperation. This is demonstrated well by Waterton/Glacier International Peace Park where there are regular interpreter exchanges either for the season or on specific days of the week. Also, interpreters from both parks lead day-long international hikes, with a lunch stop on the border in which Americans sit in Canada, Canadians sit in the USA, and foreign visitors can sit either side or on the boundary if they wish.

5. A highly visible, high-level *joint activity* promotes staff goodwill and morale, and goes well with the public. A joint annual field day for the public, or even a joint annual staff picnic, seems like a good practice. Alpi Marittime Nature Park (Italy) has an annual event (a rye festival), celebrating the cultural traditions of an ethnic group that is now located mainly across the border in France, and is joined in this by Mercantour National Park in France.

- Difficult terrain, inaccessibility, lack of roads or rail across national frontiers impedes interchange.
- Different (sometimes conflicting) laws may reduce the effectiveness of TBC.
- The need for cooperation may slow the response to emergency situations calling for rapid decisions.
- Religious or cultural differences can cause misunderstanding and language barriers may have to be overcome.
- Differential commitment and resources on each side of the border can lead to a dominant-vs.-weak situation.
- The different levels of professional standards for corresponding staff may impede real equal-partner twinning.
- Differences in the authority given to the two park superintendents or directors may produce difficulties in TBC.
- A lack of parity with regard to the ratification of international protocols or conventions may prevent their being used for TBC.
- Two or more countries may be at different stages of economic development and have incompatible policies related to resource utilization vs. resource protection.
- Armed conflict, hostility, or political tension make TBC difficult or impossible.
- Technical incompatibilities in communication, fire suppression equipment, GIS systems, etc., may impede TBC.

Box 34.2. Difficulties impeding transboundary protected area cooperation (based on Hamilton et al. 1996).

6. Regular *joint technical meetings,* seminars, or training programs encourage information exchange, development of a transborder spirit, increased staff morale, professional upgrading, and cooperative development of strategies and materials. A good example is the Northern Borderlands Managers' Workshops involving professional staff from the U.S. National Park Service, Parks Canada, U.S. Forest Service, Alaska State Parks, British Columbia Parks, Yukon Parks, and First Nation co-managers, who focus on the large World Heritage Area that crosses all these jurisdictions (Wrangell-St. Elias/Kluane/Glacier Bay/Tatshenshini-Alsek World Heritage Complex).

7. *Joint research and monitoring* is a positive and non-threatening activity and can be a good base on which to build other collaboration. Even when the research is done by outside organizations or individuals, it is usually more effective when done without regard to an artificial (political) boundary. Shared research results for park management are significant and needed benefits. Good examples are in Tatransky/Tatrzanski National Parks in Slovakia and Poland, and in Krkonose/Karkonosze in Czech Republic and Poland. The biosphere reserve designation in these parks fosters research cooperation both in the core zone and buffer zone, since this UNESCO (United Nations Education, Scientific, and Cultural Organization) program encourages collaborative scientific activity.

8. *Compatible* or, preferably, *joint management plans.* While joint management plans may not be feasible due to the different timing of establishment of the respective areas (or other factors), they need to be compatible on major issues such as fire management, pest species control, and management of fauna that cross borders (e.g., France's La Vanoise/Italy's Gran Paradiso for ibex recovery and management).

9. *Collaborative professional development* of staff through staff exchange and joint training programs are very desirable, and develop "ties that bind." Hohe Tauern in Austria has joint training activities that realize economies by using qualified trainers once instead of three times, in each of the three state jurisdictions, Carinthia, Salzburg and Tyrol. It has developed a "training academy." Staff exchanges are in place in Mercantour/Alpi Marittime (France/Italy), including language instruction.

10. It is desirable to have a *written agreement on mutual assistance* in dealing with illegal transborder activities such as poaching, drug movements, and timber trespass, and with emergency situations such as fire suppression and search-and-rescue operations. Waterton/Glacier International Peace Park has a written agreement on the latter two areas of concern, and it is a major item on the USA/Mexican border, where a joint Borders 21 Project is working out binational collaboration on all of the abutting border protected areas in the Big Bend region of Texas, or at Organ Pipe Cactus National Monument in Arizona.

11. Each protected area agency needs to *sanction time allocation* of staff for the necessary coordination work, which inevitably has a substantial amount of discussion and pre-activity meetings. In view of the benefits, this must not be regarded by higher agency officials as unproductive wheel-spinning.

12. *International conventions and protocols* should be used where possible to support and foster effective TBC. These include World Heritage designation, Convention on Migratory Species, Convention on International Trade in Endangered Species, Convention on Wetlands of International Importance (Ramsar), Biodiversity Convention, and Man and the Biosphere Program (especially biosphere reserves). These designations not only give a higher profile and status but another layer of possible protection, as is the case in the Eastern Carpathian International Biosphere Reserve, Ukraine, Slovakia, and Poland (Fall 1998).

13. *Support of an nongovernmental organization (NGO),* preferably one that can work both sides of the border, can help to develop and maintain a constituency for the joint park. This is well illustrated by the Rotary Club International in the case of Waterton/Glacier. Rotary conceived the peace park idea and pushed each government to action. It continues to be active and is currently attempting to eliminate the swath of cut vegetation that marks the international border. The Mountain Institute plays a nurturing and training role in Makalu-Barun (Nepal)/Qomolangma (China), and carries out projects with the traditional people living within and around the protected areas. It assists in securing donor support for park-related activities involving local self-help projects. The International Tropical Timber Organization was instrumental in securing donor funds to help make operational the Lanjak-Entimau/Bentuang-Karimun protected areas in Sarawak, Malaysia, and Kalimantan, Indonesia. NGOs developed a Danube Charter that was instrumental in the establishment of the tri-lateral Morava-Dyje wetlands (Czech Republic/Slovakia/Austria). IUCN and the World Wide Fund for Nature have both played effective roles in assisting border parks, particularly in developing countries. In these cases there is often technical and financial assistance in the formulation of management plans. It is an IUCN program activity to promote transborder protected area establishment and cooperative management. For instance, it is promulgated in the IUCN European Action Plan (Synge 1994), and is the focus of a new publication in the IUCN World Commission on Protected Areas (WCPA) guidelines series (Sandwith et al. 2001).

14. While an outside group can do much to keep agency administrators and others higher on the bureaucratic or political ladder supportive of the transborder park idea and TBC, the park units themselves must direct attention to this matter. Timely and regular *communication upward* to higher decision-makers and other agencies that may adversely affect the park (e.g., tourism, transportation, energy and mines, forestry, agriculture) is extremely important. International field days, publicizing successful cooperative projects, hosting global meetings, and appropriate use of newsletters have been used toward this end. Many of these are well illustrated in the Australian Alps Liaison Committee activity.

15. The same communication effort must be carried out when dealing with *community support,* which needs to be fostered at every opportunity. Benefits of the protected areas need to be continually explained. Consultation with the community in planning for new management activities is becoming increasingly the standard park policy. Local NGOs often play a significant role here, as shown in Makalu-Barun/Qomolangma, and indigenous community co-management which is gradually taking place in Kluane/Wrangell-St. Elias.

16. *A formal agreement* between the political entities that gives a mandate to cooperate is needed in addition to a cooperating relationship between cross-border staff, for personnel change all too often. Poland and Slovakia have such as agreement for the Tatra Parks. The Australian Alps National Parks has a comprehensive memorandum of understanding, recently renewed after ten successful years in place. La Amistad International Park (Costa Rica/Panamá) has presidential ratified agreements and a binational technical commission.

17. Some kind of *advisory, coordinating, or oversight group* has a significant role to play and can be supportive to the directors or superintendents of the respective units. (The Australian Alps Liaison Committee performs this function, and does it extremely well; in the case of Mercantour/Alpi Marittime, the Italian park director is a voting member of the management and policy board of the park across the border, and the French director is an *ex officio* invitee to the Italian policy committee.)

18. Having *funds that support and therefore promote joint research or joint management projects* is extremely desirable. These may come from outside, as is the case in Krkonose and Karkonosze where Global Environment Facility funds support cooperative projects conserving biodiversity; or be provided by the respective agencies or ministries but earmarked for cooperative activities to be awarded and supervised by the coordinating body, as is the case for the Australian Alps Liaison Committee (currently around US$250,000 annually).

19. At the highest level of TBC there needs to be a *full or part-time coordinator,* perhaps on a rotating basis as is done by the four agencies in the Australian Alps, for their full-time coordinator.

20. For the highest degree of collaboration a formal agreement is necessary, but it alone is not sufficient. *Enthusiastic, friendly relationships* between the respective superintendents or park directors, and staff at all levels must exist, or TBC will founder, in spite of agreements. This “intangible” is imperative.

I must say that in my travels for WCPA, and dealings with protected area personnel, I have encountered only friendliness and enthusiasm among staff within the protected area and across to neighboring protected areas. Park professionals by nature seem well equipped to promote effective cooperation across all boundaries, whether they be international, interstate, interagency, or across into the neighboring communities.

[Note: This paper is based largely on *Parks for Peace: Transboundary Protected Areas for Peace and Cooperation* (Sandwith et al. 2001).]

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35 Crossing boundaries to promote stewardship through international partnerships and exchange

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Introduction

As protected areas managers worldwide face new and increasingly complex challenges, there is a growing need to learn from the experience of counterparts working in other regions of the world. Focused exchanges and partnerships, built on the principle of mutual learning, can make an important contribution to fostering innovative conservation strategies, building effective partnerships and coalitions, and strengthening the capacity of participating institutions.

This paper reports on the work of Quebec–Labrador Foundation/Atlantic Center for the Environment (QLF) over the last two decades in conducting a multi-faceted international exchange program focusing on *land conservation and stewardship*. The program works with conservation practitioners and community leaders to develop new strategies for conservation of natural and cultural heritage. Working in partnership with local institutions, the program links the organization's domestic region of northeastern North America with four target regions: Central Europe, Latin America, the Caribbean and, most recently, the Middle East.

Background

QLF is a private, non-profit organization whose mission is to support the rural communities and environment of eastern Canada and New England (USA), and to create models for stewardship of natural resources and cultural heritage that can be applied worldwide. Established in 1963, the organization has decades of experience working in rural communities. In the early 1980s, QLF established an international program as a means of linking its community-based conservation projects with those in other regions of the world.

Building on this experience, and responding to the growing interest in stewardship expressed by its partners and past exchange participants, in 1993 QLF launched a multi-faceted international exchange program focusing on the theme of land conservation and stewardship. The broad goal of the program is to advance land conservation and stewardship in QLF's domestic and four target regions.

"Stewardship" means, simply, people taking care of places. More specifically, it can be defined as "efforts to create, nurture, and enable responsibility in landowners and resource users to manage and protect land and its natural and cultural heritage." Stewardship taps our basic human impulse to care for our home and its surroundings—be it a parcel of land, a neighborhood, or a historic monument, or the larger area of a watershed, mountain range, or stretch of coastline. It builds on our sense of obligation to other people: our family, our community, and future generations.

The stewardship approach provides a means of reaching beyond the boundaries of conventional protected areas. The stewardship concept draws on an array of tools to conserve natural and cultural values. These tools include education, voluntary management agreements, the use of deed restrictions (e.g., conservation easements and covenants), public–private partnerships in protected areas management, and

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outright acquisition of property by private organizations (Mitchell and Brown 1998; Diehl and Barrett 1998; Endicott 1993).

QLF's international program on land conservation and stewardship relies on an array of methods for training, technical assistance, research, and exchange, which are designed to reinforce each other. These include: an annual fellowship program in northeastern North America, on-site workshops on stewardship topics, retreat meetings for fellowship alumni, partnership assignments with alumni, community problem-solving workshops, and study tours for local leaders. Each of these projects is founded on the principle of true exchange—one in which learning can take place on both sides.

Since the program's inception, several hundred conservation and community development practitioners from these regions have participated in fellowships, workshops, and peer exchanges. QLF's growing cadre of alumni includes protected areas managers as well as leaders of nongovernmental organizations (NGOs), local and regional government agencies, and community organizations.

The program has evolved differently in each region, responding to the particular conditions affecting stewardship and the needs identified by our partners, and also reflecting geographic factors. Although distinct, QLF's projects in each target region build on each other through the gathering of information about common challenges and strategies. QLF's program in Central Europe, described briefly below, illustrates how the diverse program methods have worked together, and the value of international partnerships during a time of dramatic change in that region.

A joint program to promote landscape stewardship in Central Europe

In Central Europe, the sweeping political changes of the early 1990s set in motion a number of forces that are shaping the region's landscapes. These include: re-privatization of land; a rapid increase in development pressure for housing, transportation, and tourism; changes in agricultural patterns; accession into the European Union; and the devolution of power from central governments to local and regional governments (Brown and Mitchell 1997).

Protected area managers in the region face many new challenges including changes in land ownership patterns within protected areas, new public attitudes toward planning controls, and increasing public scrutiny of management measures. At the same time, new opportunities for the region's protected areas systems include the creation of new protected areas as part of the land redistribution process, the upgrading of designations, improved management through NGO–government partnerships and bilateral cooperation, and the emergence of private land conservation.

Now in its tenth year, QLF's program in Central Europe encompasses an array of training, technical assistance, professional exchange, and community-based planning projects. Its geographic focus is the Czech Republic, Hungary, Poland, and Slovakia, with occasional participation from other countries in the region, including Ukraine, Romania, and Slovenia.

QLF's principal partner in developing the program has been the Environmental Partnership for Central Europe Consortium (EPCE), which is operating in the Czech Republic, Hungary, Poland, Romania, and Slovakia. In addition, QLF has worked with local-partner NGOs on projects such as landscape stewardship exchanges and other workshops. QLF's program in Central Europe has received support from private foundations, including the Rockefeller Brothers Fund, the German Marshall Fund of the United States, and the Trust for Mutual Understanding, and from public agencies, such as the U.S. Information Agency. A more detailed description of the joint program described here can be found in (Beckmann et al. 2000).

A core element of the program has been a fellowship on land conservation and stewardship, which has been offered annually for one or more target regions since 1993. Each fellowship brings 5-8 conservation practitioners from one of the target regions to the New England region of the USA, for an intensive month-long program incorporating seminars, a study tour, individual placements with host organizations, and a group case-study project. The program can be characterized as a group learning process in which the Fellows learn from each other as well as from the North American counterparts with whom they meet and work. Since 1993, QLF has conducted five Central European fellowships, reaching 37 practitioners from the region.

To help this growing cadre of Fellows to build and maintain a network after they return home, QLF and EPCE have convened four alumni retreat workshops in Central Europe. In addition, they have held three "Tools for Stewardship" workshops in the Czech Republic and Poland, which have reached an expanded group of practitioners, local leaders, landowners, and resource users. Further reinforcing the fellowships and workshops has been a series of technical assistance assignments in areas related to land stewardship, such as recent assignments with emerging land trusts in the Czech Republic.

Another key element of the program is the landscape stewardship exchange, a week-long community problem-solving exercise. Through the exchange, an international team spends a week in a rural community or micro-region to learn about and advise on a problem identified by people in the community. The model relies on a combination of community organizing at the local level and the outside perspective provided by the international team to stimulate public participation and a dialogue among diverse stakeholders.

To date, QLF and local partners have conducted seven exchanges in Central Europe in sites in the Czech Republic, Slovakia, and Poland. Typically, these exchanges have been held in communities in or near protected areas and have addressed themes related to rural development and landscape conservation. All but one of the exchanges have been held in border regions and have included a focus on trans-boundary cooperation. Sites and focus topics have included:

- Palava Protected Landscape Area, Czech Republic (1994): Enlargement of the Palava Biosphere Reserve;
- White Carpathian Mountains, Czech Republic and Slovakia (1995): Revitalization of rural communities in the Bile/Biele Karpaty Protected Landscape Area;
- Kvacany Valley, Slovakia (1995): Alternatives to large-scale development for recreation near the High Tatra National Park;
- Jizera Mountains/Frydlant, Czech Republic (1997): Balancing tourism and recreation with nature conservation in a fragile mountainous landscape;
- Morava River Floodplains, Czech Republic and Slovakia (1999): Development options to reduce flood risks in the lower Morava River basin, a tributary of the Danube;
- Zawoja/Babia Góra National Park, Poland (1999): Building cooperation between Babia Góra National Park and surrounding communities in Poland and Slovakia; and
- Czech Karst Protected Landscape Area, Czech Republic (2000): Sustainable development and growth management in the Czech Karst Protected Landscape Area.

Newer elements of the program have included a series of workshops and traveling seminars for local leaders (e.g., mayors, rural development professionals, protected area managers, and conservationists) from rural communities where the landscape stewardship exchanges have taken place.

Discussion

The accomplishments of fellowship alumni after they return home, follow-up activities in landscape stewardship exchange host areas, and examples of ongoing cooperation through contacts made during the program are among the indicators of its impact.. Based on the observations and reports gathered to date, examples of how QLF's international Program on Land Conservation and Stewardship is contributing to advancing stewardship in its target regions include:

- ***Strengthening the capacity of local institutions and contributing to leadership development.*** In each of the target regions, past Fellows are playing leadership roles with NGOs and public agencies concerned with conservation, including park agencies, and National Trusts.
- ***Supporting a transfer of innovations among conservation professionals from these regions.*** One important area has been the transfer of tools for private land conservation, which program participants have adapted to the context of their home countries. In another kind of example, Czech and Slovak alumni have adapted for use in their countries a technique called "community visioning"—a methodology developed in northern New England.
- ***Helping to create new legal and institutional mechanisms for encouraging stewardship practices in diverse settings.*** Returning home with new ideas, many of our past Fellows are influencing the legal and institutional context for conservation to meet the needs and realities of their conditions—for example, introducing new legislation for private reserves, establishing a national fund for land conservation, and building coalitions to address problems.
- ***Encouraging citizen participation in environmental problem-solving***. International problem-solving exercises and case-study projects have proven to be a powerful vehicle for bringing together diverse stakeholders in a productive and ongoing dialogue about their community's future.
- ***Fostering dialogue and cooperation among concerned individuals and institutions.*** An important contribution of the exchange programs is in the area of citizen diplomacy, both within and between regions. By bringing together people from diverse geographic and ethnic backgrounds to work together on areas of shared interest, these programs have helped to foster mutual understanding. More broadly, the fellowships, workshops, and exchanges have spawned regional networks and inter-regional cooperation among peers working on similar problems in diverse settings around the world.

Two decades of experience with international exchange programs has revealed a number of strategies that work well. These include: building strong partnerships with cooperating organizations, making a long-term commitment to working in a given region, developing a thematic focus, linking projects activities so that they build on and reinforce each other, and remaining adaptive over time. Also important to the program's effectiveness have been an emphasis on process rather than the technical aspects of solving conservation problems, and a reliance on cross-sectoral, interdisciplinary approaches.

Conclusion

Since it was launched in 1993, QLF's international exchange program on land conservation and stewardship, which links five different target regions, has reached several hundred practitioners. The program has demonstrated the value of international exchange and partnerships in fostering a productive exchange among practitioners and contributing to improved stewardship practice on all sides. More opportunities to exchange ideas and learn from the successes and failures of national and international counterparts are needed to strengthen this growing movement.

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36 A cross-national comparison of protected natural area systems in Russia and the Baltic States: diverging systems ten years after the fall of the Soviet Union

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Introduction

The Union of Soviet Socialist Republics (USSR) spanned two continents from 1917 until 1991, incorporating the Baltic States (Latvia, Lithuania, and Estonia) just after World War II. A protected area network developed across all 15 nations, including ecosystems as diverse as forests, coastlines, mountains, tundra, and steppe. In the mid-1980s the long-range plans for each nation included expanding all types of protected areas. Since the fall of the USSR, each nation has redefined its form of government, and thus too the system that protects natural resources. Russia expanded the two pillars of its protected area system, *zapovedniks* (strict nature preserves) and national parks. Despite tremendous economic challenges, Russia has focused on and maintained a tradition of ecological research on zapovedniks. Natural resource managers in the Baltic States face a different set of challenges. The expansion of their *reservats* has been more modest (the Baltic States use the term "reservat," but for the rest of this paper I will use "zapovednik" with some risk until an international agreement is struck on terminology). Latvia and Lithuania have focused on a system of national parks which preserve cultural as well as natural resources.

Central to explaining the premise that Russia, Latvia, and Lithuania have divergent issues in protected area management is identifying emergent social forces during the decade of transition and democratization. Comparative works outline factors such as historical forms of government, ties with the West, natural resources, and the presence of minorities (e.g., Hill 1994; Hough 1997; Juviler 1998; Matveeva 1999). Common cultural values in each nation continue to be the importance of nature, access to wildlands, and concern for natural resource policy. A comparison of these three nations highlights the influence of culture, economics, and political choice on protected areas. Toward that end, each country is briefly described in sociopolitical terms and then their protected area strategies are analyzed.

Methods

Case study methodology (GAO 1990; Yin 1994) directed me to use data from Freedom House (an annual survey that uses a seven-point scale to rate "political rights" and "civil liberties"; Freedom House 2000) and literature that details the unique socioeconomic conditions influencing the process of democratization. The information on protected area policy is through archival research, elite interviews, and roundtable discussions in Russia in 1995, 1999 and 2000; and through elite interviews in Lithuania and Latvia in January 2001.

The Soviet-era system

The three nations inherited the Soviet system of protected natural areas, including local, regional, and national designations of natural, historical, cultural, aesthetic, and recreational significance. Two basic areas are utilized in this study: zapovedniks

From **Crossing Boundaries in Park Management: Proceedings of the 11th Conference on Research and Resource Management in Parks and on Public Lands,** edited by David Harmon (Hancock, Michigan: The George Wright Society, 2001).

and national parks. Established for scientific research in 1919, zapovedniks were defined as areas that exclude virtually all anthropogenic disturbance, including wildlife management, species introduction (on most areas), extractive resource use (industrial or personal), and recreational activities. Their primary purpose was to preserve typical and unique ecosystems and conduct baseline research in ecology (Pryde 1972; Weiner 1988). These goals have persevered through seven decades of Soviet rule, including two devastating reorganizations (Borieko 1993; Borieko 1994), and continued to dominate the management goals of zapovedniks in the 1990s (Shtil'mark 1996; Weiner 1999). Additional goals have been added to zapovedniks in all three nations to include environmental education and assisting in the preparation of environmental impact assessments. The expanded goals are intended to increase the zapovednik response to local and regional needs (Ostergren and Hollenhorst 1999; Östergren 2001).

The second important category of protected area is the national park. Much like other national park systems in the world, the national parks under study here are geared toward natural, cultural, and historic preservation, as well as nature-based recreation (Chebakova 1997). National parks are a relatively new feature in the former USSR. During the late 1960s, a social movement for outdoor recreation encouraged thousands into the forests. The inevitable pressure on zapovedniks to allow recreation jeopardized their pristine qualities. In partial reaction to the demand for public recreation areas, the USSR designated the first national parks in 1971, one each in Estonia, Latvia, and Lithuania (Pryde 1972; Gaava et al. 1984). Russia started designating national parks in 1983. These may include villages or agricultural activities (IUCN 1994).

Diverging protected area priorities

Russia. The limited form of democracy in Russia has been described as a "delegative democracy" (O'Donnell 1994). As a delegative democracy, the regime has free and contested elections but, once elected, the president is able to govern with relatively little input from the general public (Tsygankov 1998). Juviler (1998) states that Russia's democracy lacks executive accountability, and economic and civil rights have shown slow, sporadic progress. Nonetheless "ten years after *perestroika*, Russia is more free and more democratic than it was before" (Sakwa 1996, 377).

Russia is rated as "partly free" (Freedom House 2000). Studies cite an emergent, but fragmented presidentialism; powerful, self-serving ministries; a tenuous pluralism; and the short history with open elections (Frank 1994; Fish 1995; Sakwa 1996; Biryukov and Sergeyev 1997). The Freedom House civil liberties rating is "5" (out of 7) for a variety of reasons. The media wars during elections have been equally caustic to all members of the Duma, and the state pressures media outlets to present material in a "pro-government" light. Other fundamental problems include corruption, crime, human rights violations, and the slow reform of the judicial system.

Despite tremendous challenges, Russia has invested in its zapovednik system. Since 1991, the system suffered a two-pronged assault of draconian budget cuts and increasing pressure to utilize the reserves' natural resources (Krever et al. 1994). Results of a 60-80% reduction in federal funding include the elimination of helicopter support, infrastructure degradation, a decrease in wages, and a decline in research (Östergren 1998). However, the most dangerous threat to the system emerged from social conditions (Pryde 1997). As the borders of the USSR became more permeable, poachers accessed world markets for illegal trade. Furthermore, as people lost their income, hunting and fishing in the zapovednik "pantry" was often a matter of survival (Ostergren and Shvarts 1999). However some changes after 1991 were positive. For example, newer zapovedniks are utilizing outreach programs in schools and "on-site" environmental education. Although enlarging a struggling and impoverished system seems counterintuitive, the Russian system has expanded from 77 preserves in 1989 to 99 in 2000.

Russian national parks are zoned to accommodate multiple uses, although 50-100% of a national park is protected for natural (undisturbed) conditions. Road building and resort-type lodges for the public are permitted within the tourism zones. Generally, the 35 national parks were a minor consideration for funding by the then-parent Federal Forest Service. One result of scarce human and financial resources was that the managers have turned to international aid and voluntary help to conduct basic maintenance. The most significant recent event affecting Russian national parks was that in May 2000 President Vladimir Putin abolished the Federal Forest Service. Although national parks had been the poor stepchildren in the Forest Service, they have now been merged into one department with the zapovedniks and have lost their independent home.

Also in May 2000, President Putin eliminated the State Committee of the Environment. This institution was the umbrella agency for zapovedniks. The preserves and national parks have been placed in the Ministry of Natural Resources (a frequent target of criticism by the State Committee of the Environment). Either the events will energize the environmental community, or public participation in protected area policy-making will sink to new levels of ineffective protest. In general, Russia has been characterized as lacking active participation in public affairs and suffering from a weak civic community (Marsh 2000). Despite the bleak prospects for protected area agencies housed in a "pro-development" ministry, placing the sister systems within one department may ultimately lead to a cohesive, unified national protected areas network. However, Director Stepanitsky appears to have no intention of merging the two systems; rather, their missions may be highlighted and viewed as necessary complements.

Latvia. The independence of 1918-1940 set democratic roots deep in Latvian political culture. However, Premier Karlis Ulmanis suspended the parliament in 1934 to right a flagging economy, and then the Soviet Union annexed the Baltics in 1940 (Runcis 1999). Civil society remained a strong force, as active dissidence and social organizations emerged in the late 1980s during Soviet President Mikhail Gorbachev's policies of *perestroika* and *glasnost*. Eventually, members of various organizations united to form the Latvian Popular Front in 1988, awakening a national move for independence. The eventual formation of 20-plus parties and early elections to determine a 100-member parliament boded well for democracy (Nørgaard et al 1996).

Democratic institutions in Latvia have been refined and tested over the decade. Freedom House describes Latvia as "free" with extensive political rights and civil liberties. The parliament has exchanged hands several times; in June 2000, it elected the country's first female president, Vaire-Vike Freiberga. The shifting coalitions in parliament are accompanied by stable political parties and high voter participation. Although the judiciary is weak, the press is free and prolific, social organizations assemble without harassment, and human rights are guaranteed. The biggest concern for civil liberties are the difficulties for the mostly Russian ethnic minorities (Linz and Stepan 1996; Runcis 1999). However Plakans (1997) suggests that the interethnic problems are less of a concern than many analysts suggest, and recent developments suggest that the Latvian government is streamlining the immigration process. For much of rural Latvia, forest culture, wildlife, nature, timber, and a host of forest products remain intertwined with economic and personal health. The expanded protected area system will remain an important part of sociopolitical decisions in the coming decades.

Lithuania. The country is rated by Freedom House as "free" with extensive political rights. Parliamentary elections have produced a range of political parties and institutional processes. The media is very free from state intervention (Girnius 1999). Lithuania rates slightly lower in civil liberties because, although social plurality is guaranteed, the obstacles to full democracy are a weakness in applying the law, the poor condition of political debate, and the deep divide between Communists and non-Communists (Krikus 1997; Girnius 1999). The most recent elections brought back the "left" (members of Communist party before 1990) into the parliament. Some officials are worried about the abrupt shift in government policy with regard to protected area management, but the national policy direction appears to be set.

Contributing to Lithuania's peaceful move to democracy is its brief history of independence from 1918-1940 and the development of a constitution (Krikus 1997). Unfortunately, the country slipped into authoritarianism in 1926 and any independence was doomed in 1940 with its annexation by the USSR. In the late 1980s, the strong Catholic Church supported activists and underground newspapers until Lithuania elected the first non-Communist party to its legislature anywhere in the USSR (Krikus 1997). Lithuania was relatively quick to emerge as a functional democracy. The 137-member parliament and directly elected president are balanced by an independent judiciary (Girnius 1999). Natural resource management in this small nation has emerged as a high priority.

Lithuanian and Latvian protected areas

In general, the people in these two democracies are faring much better than their Russian counterparts. Ties to the European Union are increasing and foreign investment topped US$1 billion during 1995-2000 (including Estonia; Maldeikis and Rainys 2000). Although Latvia and Lithuania should not be casually lumped together for analysis, in the field of protected area policy they appear to be more similar, and thus mutually distinct, from conditions and issues in Russia. Keep in mind that Latvia and Lithuania (as well as Estonia) have a host of distinctive characteristics (Maldeikas and Rainys 2000).

Zapovedniks in Latvia and Lithuania have remained true to the traditional course of highly restricted access and conducting ecological research. The greatest growth has been in national parks and regional nature parks. One of the obvious goals of both countries is that their ministries of the environment seek to increase foreign tourism. Not only are the national parks expanding in scope and size, but the local populace is encouraged to capitalize on the trade. Bed-and-breakfast operations are attracting foreigners, and active programs have been developed to preserve and highlight traditional culture. Nature parks emphasize non-consumptive actives for national and international tourists. Literature and maps are available in English and German and highlight the natural and cultural attractions.

The emerging conflict for national park managers takes two forms. Timber remains a significant resource as an export to Europe. It is important to keep in mind that the Baltic region has been settled for centuries and does not possess the extensive wildlands of Russia or the USA. The forests have been harvested at one time or another and many areas have been replanted. National parks have been defined with logging "zones." The obvious question is how much can an area be logged and still maintain a semblance of protecting natural resources? The national parks receive an income from sales of timber, which contributes to a conflict of interest. NGOs are active in seeking a balance, and in some national parks the logging practices actually maintain meadows that preserve the landscape and enhance grazing for wildlife. As Ugis Rotbergs (of the World Wide Fund for Nature's Latvia project) observed, it is impossible to determine exactly what is the "natural" state of the Baltic region, so WWF supports a range of conditions that preserve a "best guess," including culturally or traditionally meaningful conditions. The contrast to Russia is evident.

The second major challenge is in land ownership. Unlike Russia, land restitution to pre-World War II owners created an extensive pattern of in-holdings. In addition, city dwellers are purchasing land in, or near, national parks for aesthetic and recreational values. Compared with Lithuania, Latvia appears to have been more successful at limiting in-holdings for natural areas, but the cultural zones are similar between the two nations. Future challenges to management will include the friction between preservationists wishing to maintain the old character of small villages and new residents wishing to improve their homes. For instance, if a landowner passes away in a "culturally significant" village and the heir would like to add plumbing, an indoor toilet, or new windows, what right does the national park have to restrict changes so that the home remains consistent with its old character? Land zoning is in its infancy and the concepts and restrictions are not nearly as sophisticated as in, say, Switzerland, with its severe zoning requirements.

Conclusion

The distinctions between Russia and the Baltic States lie in fundamental differences in interpretation of land ownership, land use, and economic affluence. With new challenges to seek funds, Russian national parks may well increasingly pursue foreign tourism, although it appears that the unique system of zapovedniks will persevere. Latvia and Lithuania have significant land management challenges ahead, as private land ownership and pressure to extract timber increase in the next ten years. The fall of the USSR has provided an excellent "experiment" in the evolution of protected area policy over time under a variety of sociocultural conditions.

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37 Emscher Park, Germany — expanding the definition of a "park"

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In Emscher Park, Germany, the creation of a "landscape park" has been used to drive the restoration of one of the most degraded landscapes in Europe. It has become "a symbol as well as a stimulus for urban, economic, social, and environmental change" (Brown 2001, 66). The experience suggests how powerful the concept of a "park" can be once we move beyond the boundaries of the traditional American definition.

Setting the stage

The Ruhr Valley in western Germany was once the country's industrial heartland. Its coal mines and iron and steel mills powered the military–industrial machine during two world wars, and was the engine for the German "economic miracle" during the 1950s and 1960s.

However, by the 1970s the international markets had begun to change and the region's industries were becoming less competitive. Mines began to close. Factories that had operated night and day fell silent. Their gates closed and they became "brownfield" sites in need of restoration.

The extensive mining in the area had created the danger of subsidence, so rather than install underground sewers that might be breached, authorities had channelized and canalized the Emscher River creating, in essence, an open sewer carrying both industrial and human waste.

The landscape through which the Emscher River flows is basically flat. The main features are human: the industrial buildings that rise for ten stories or more, and slag heaps the size of small mountains.

About two million people live in the region, and in the late 1980s the unemployment rate exceeded 15%. The ecological degradation was mirrored by psychological resignation among much of the population.

In 1989, the Land (roughly equivalent to a state in the USA) of North Rhine-Westphalia created the International Building Exhibition – Emscher Park ("IBA" in the German acronym). It was to be innovative in many ways, including:

- Using ecology as the central organizing focus for the regeneration of the region's economy as well as its environment;
- Turning industrial wastelands into a regional network of open space, recreation, and cultural resources; and
- Being the largest renaturalization project in Europe, and one which is rare in the world for undertaking brownfields restoration on a regional, rather than site-specific, basis.

This was a highly complex initiative involving the creation of an entirely new administrative structure with a ten-year "lifespan," which used seminars and international competitions to generate innovative ideas.

Although little has been written in English about the Emscher Park experience, increasing numbers of American professionals are making the pilgrimage to see this

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project for themselves. Given the scope, complexity and unusual nature of the project, it is not surprising that most of us have only scratched the surface—and each of us has seen the project through our own prism. Nevertheless, I would like to focus on a few main ideas that relate to the special interests of the George Wright Society and the conference theme of "Crossing Boundaries":

- The power of ecology as a central focus and integrating concept for a regional redevelopment initiative;
- The impact of using art in the landscape to signal a new policy approach; and
- How the creative re-use of industrial buildings can play a powerful role in changing the mind-set of local residents. This may have been Emscher Park's most impressive accomplishment.

The power of ecology as an integrating concept

Within the Ruhr region, the IBA focused on the Emscher River which, with its tributaries, flows for about 218 miles**.** This shared resource provided a common focus for 17 local authorities in an area of approximately 200 square miles. A central aim of the project was to clean up the river. Now that mining has ended in much of the region, underground sewers are being installed to carry waste, and the river is being renaturalized. The concrete channels are being removed and natural vegetation is being restored. This is important for water quality and management, and for habitat. Perhaps even more importantly, it provides a highly visible symbol of positive change.

Another central aim of the project was to integrate and develop existing open spaces to create a regional park system that would include seven green corridors running north–south and east–west through the region. The audacity of this plan becomes clear only when one realizes that the open space at the heart of this network comprises former industrial sites, their connecting transportation system, and the old slag heaps. This was to form the basis for a park system intended to be of "European significance."

Several thematic tourist driving and biking routes were created, including the "Route of Industrial Culture" which includes routes with themes such as the "Route of Industry and Nature." These routes serve several purposes: to create and improve green infrastructure, provide more recreational opportunities, appeal to tourists, and increase the understanding of the region's heritage among local residents as well as visitors.

It is important to note that many of the sites that have become features of interest for both tourists and local residents were surrounded by residential areas, but that the residents were only allowed within the walls if they worked there. Many people had lived in the viewshed or within earshot of these facilities all of their lives and never been on their grounds until the creation of the landscape park.

The ecological theme was integrated into economic and residential development as well—with a pronounced emphasis on energy efficiency and, in particular, the use of solar technology. A prime example is found in Rheinelbe, where a stunning building, which incorporates state-of-the-art solar technology, serves as an incubator for new solar technology businesses. It is a beautiful space unto itself, but serves the additional purpose of providing an internal walkway connecting the former colliery (which now has public open space and offices) with the town.

The Duisberg docklands, which have been falling into disuse as the industrial activity in the region declines, are also illustrative of this theme. A major urban redevelopment initiative has been undertaken with the goal of "bringing water back into the life of the city in an active way." Among the ways this is being done are creating a multi-use urban waterfront, including energy-efficient offices, creating side canals (with naturalized areas) as the site for new housing (Figure 37.1), and damming the canal to provide an area for swimming.

Figure 37.1. New housing along newly created side canal in Duisberg. Photo by the author.

Adaptive reuse of industrial buildings

The region's identity—historical, economic, and cultural—was associated with industrial plants, collieries, foundries, slag heaps, and the like. So immense efforts have been made to preserve and reuse them as "industrial monuments." It was important to help the local residents understand that the ecological devastation of the region had been a function of a particular set of geographic, political, and economic forces, and that the people who had created and sustained these industries were inventive, skilled, and strong. Rather than questioning the past, IBA challenged residents to consider how to use those valuable qualities to take the region into the new economy.

A few examples of the manner in which industrial sites were reused will provide a sense of the inventive and imaginative power brought to bear by the IBA.

The Oberhausen Gasometer, which had been used to store gas produced by nearby blast furnaces, closed in 1988. Over 385 feet in height and 220 feet in diameter, it has become Europe's largest, and perhaps most unusual, exhibition space.

An internal elevator allows visitors to see the interior of the space as they ascend to the roof, from which they have a sweeping view of the entire area. The windows in the ceiling form a pattern not unlike the "rose window" of a cathedral, and changeable colored panes are used to enhance the effect. Residents and visitors alike are awed by the scale and unexpected beauty of the interior of this behemoth.

The Zollverein Colliery was actually known as the "cathedral of labor." One of the most famous symbols of the mining industry in Germany, it closed in 1986. Its Bauhaus-inspired buildings have been adapted for many new cultural uses, including a museum of coal production, a center that features exhibitions of the best industrial design, a citizens' center, and a fine restaurant. A solar-powered Ferris wheel carries visitors through part of the plant and high above it to catch the view. Hiking trails connect the Colliery to the nearby community.

The Duisburg-Nord Industrial Landscape Park *(landschaftspark Duisburg-Nord)* contains well over 500 acres, most of it open space. Here visitors can explore a blast furnace, where one cannot help but be awed by the skill and strength demanded of the men who once produced iron and steel here.

But this is not a static monument. Imaginative steps have been taken to provide recreational uses that would entice visitors. Walls are used to provide rock-climbing lessons. A large metal tube curves out and down and back through a wall—becoming a slide provided for children (that attracts not a few adults as well; Figure 37.2).

Figure 37.2. Children using slide in the Duisburg-Nord Industrial Landscape Park. Photos by Jennifer Petramale.

Perhaps the oddest feature to a visitor is the multi-colored night lighting. However, then one learns that the plants had been operational 24 hours per day—and when they closed, residents said "it was as though the night sky had died." This new lighting, created as a result of an international design competition, was not intended to replicate the old. Rather it is another example of the ways in which Emscher Park helps bring the past through the present into the future. It is also an example of the project's innovative use of art.

Use of art in the landscape

The IBA conducted several international competitions to select art to be placed in the landscape. This was not uncontroversial. Many people questioned whether the money used to pay artists to design night lights for former industrial buildings or sculptures atop slag heaps might not be better spent for housing or other social needs.

However, the art has helped to signal the forward-looking nature of the initiative and to provide a system of new landmarks through the landscape. Several large sculptures have been installed atop slag heaps, including the towering Tetrahedron at Bottrop (Figure 37.3). Lighted at night, they provide new reference points in the night landscape. Smaller, more intimate sculptures have been created in areas newly used for parks and recreation. They serve to draw the visitor into a landscape that had hitherto been off-limits and foreign. Some are composed of industrial artifacts found on the site, providing a more intimate connection with the site's history.

Figure 37.3. The Tetrahedron atop a slag heap in Bottrop, with active plants in the background. Photo by the author.

This is consistent with another underlying theme of the project: the importance of building and site design, which are regarded as critical factors in the regeneration of the economy and the environment. Examples abound, ranging from the former coal mine headquarters in Bottrop, which has been restored on the outside and redesigned on the inside to house a business incubator, to the bridges constructed throughout the region to provide pedestrian connections, each of which is innovative in terms of design and function.

Summary

In Emscher Park, the concept of a landscape park was used to drive the regeneration of a heavily degraded region. In so doing, it also helped to introduce residents to their culture in a new way. Many to whom we spoke felt that changing the mind-set of local residents was perhaps the IBA's greatest accomplishment—particularly important during a time of economic restructuring. Now, we were told, residents are "aware, appreciative, and hopeful."

Emscher Park can help us expand our own sense of what is possible—and suggests the powerful potential of new concepts of "parks."

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38 Bioprospecting as a conservation tool: history and background

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For millennia, people around the world have studied nature as part of humanity's never ending search for new ways to improve crops for food production, to combat disease and other maladies, and to make other discoveries that might enhance the overall quality of life on Earth. For example, more than half of the top brand-name pharmaceuticals in use in the USA in the early 1990s contained at least one major active compound derived or patterned after compounds first discovered in Nature (Grifo and Rosenthal 1997). In parts of the world where traditional healing practices remain prevalent, direct reliance on useful discoveries from nature is even more pronounced.

Recent advances in biotechnology and related sciences have generated increased activity and interest in the search for useful biochemical compounds or other potentially valuable biological discoveries in Nature—a very old practice that is now sometimes described by a new term: "biodiversity prospecting" or "bioprospecting." In contrast to timber harvesting, mining, and other traditionally consumptive uses of natural resources, research-focused bioprospecting generates value from the results of scientific study involving biological samples. This value-added approach has been enhanced also by developments in intellectual property rights laws, new biorational approaches in specimen collection and drug and other product-development research, and evolving trade practices.

Reflecting the convergence of all these developments, significant value is now attaching to research results involving biological resources found in many special habitats—ranging from tropical rainforests to coral reefs to frozen tundra to national parks and other protected *and* unprotected areas (Marrs and Madigan 1997). In some places, there is an added sense of urgency as habitats and the biodiversity alive within them are threatened or lost before potentially valuable discoveries from research activities can occur. For example, while more than half of all drugs in use have an origin in nature-based research, it also is now recognized that many of the biological species upon which such discoveries depend are at current risk of loss through habitat destruction and other causes (Grifo and Rosenthal 1997).

The collection of biological specimens for scientific research purposes is not new in U.S. national parks. The first research permit authorizing the collection of microbial specimens from hot springs at Yellowstone National Park was issued in August 1898. The current NPS regulations that apply to the collection of biological specimens for scientific research purposes have been in force since 1983 (36 Code of Federal Regulations 2.5).

The best-known example of valuable research results from "bioprospecting" in U.S. national parks was the discovery and isolation in the late 1980s of an enzyme named "*Taq* polymerase." This development resulted from research involving a sample of a tiny microbe called *Thermus aquaticus* that was first collected from a hot spring at Yellowstone National Park. "*Taq*" was used as a reference to *Thermus aquaticus*. A "polymerase" is an enzyme that catalyzes the formation and repair of DNA and RNA from an existing strand of DNA (or RNA) serving as a template. The importance of the research involving *T. aquaticus* and *Taq* polymerase was summarized in congressional testimony offered by D. Allan Bromley (then director of

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the White House Office of Science and Technology Policy and science advisor to President George Bush) before the Committee on Science, Space, and Technology, U.S. House of Representatives, February 20, 1991:

> Different kinds of research and development tend to have different kinds of returns. With basic research—the majority of which is done by individual scientists and small groups of scientists at universities—it is very difficult to predict when, where, and to whom the returns will eventually accrue. Yet even work that can seem highly abstract can have surprisingly immediate impacts. To take just one example, in 1968 Thomas Brock, a microbiologist at the University of Wisconsin, discovered a form of bacteria in the thermal vents of Yellowstone that can survive at very high temperature. From these bacteria an enzyme was extracted that is stable at near-boiling temperatures. Nearly two decades later this enzyme proved to be vital in the process known as the polymerase chain reaction, which is used to duplicate specific pieces of DNA. Today, PCR is the basis of a multimillion dollar business with applications ranging from the rapid diagnosis of disease to forensic medicine.

(It should be noted that Brock was affiliated with Indiana University when *T. aquaticus* was first discovered in 1966 (not 1968); see also Grifo and Rosenthal 1997, xiii.)

Historically, the owners or custodians of biological resources that have been used in many valuable research projects have not been compensated or otherwise positioned to share in the benefits derived from researchers' uses of biological samples (16 U.S Code 5935d). This issue first arose in connection with the use of biological samples obtained by multinational research firms from biologically rich countries in the tropics. The same issue has now arisen in the USA in connection with biological samples taken from units of the National Park System pursuant to well-established research specimen collection permits.

There are three major categories of research-related institutions that are known to have biological materials originally acquired from units of the National Park System pursuant to research specimen collection permits: (1) researchers to whom permits have been issued directly; (2) culture collections and other custodial institutions that have obtained specimens from researchers; and, (3) researchers who have obtained specimens from third parties (such as culture collections) or other researchers.

The National Parks Omnibus Management Act of 1998 (16 USC 5901-6011) mandates increased scientific research activities in the national parks and use of the results of scientific study in park management decisions (16 USC 5932). The new law encourages the use of units of the National Park System for scientific study by public- as well as private-sector scientific researchers (16 USC 5935a) and mandates development of long-term inventory and monitoring activities that provide baseline information and document trends relating to the condition of resources protected by the national parks (16 USC 5934). In addition, the new law authorizes "negotiations with the research community and private industry for equitable, efficient benefits-sharing arrangements" in connection with research activities conducted in units of the National Park System (16 USC 5935d).

Against this background, there are two sets of core issues that emerge relating to the collection of biological specimens from national parks for scientific research purposes: access and benefits-sharing.

Access

Access to biological resources in U.S. national parks for research purposes is governed by National Park Service (NPS) regulations. The NPS research specimen collection permit regulations have been implemented since 1983 (48 Federal Register 30252, 30 June 1983; 47 Fed. Reg. 11598, 17 March 1982 (notice of proposed rulemaking); 64 Fed. Reg. 46211, 24 August 1999). Issuance of a permit is based on a determination by the park superintendent that "public health and safety, environmental or scenic values, natural or cultural resources, scientific research, implementation of management responsibilities, proper allocation and use of facilities, or the avoidance of conflict among visitor use activities will not be adversely impacted" by issuance of a permit (36 CFR 1.6a). Based on public comment at the time the regulations were promulgated, NPS concluded that these determinations are "adequate to ensure protection of park resources" (48 Federal Register 30252, 30 June 1983).

The superintendent's express regulatory authority to issue permits for the collection of research specimens—with terms and conditions deemed necessary to protect park resources—provides the mechanism by which units of the National Park System govern access to their biological resources for research purposes.

"Permit" is defined under the regulations to mean "a written authorization to engage in uses or activities that are otherwise prohibited, restricted, or regulated" (36 CFR 1.4). The regulations also provide that a superintendent "shall include in a permit the terms and conditions that the superintendent deems necessary to protect park resources" (36 CFR 1.6e).

The regulations provide that specimen collection permits "may be issued only to an official representative of a reputable scientific or educational institution or a State or Federal agency for the purpose of research, baseline inventories, monitoring, impact analysis, group study, or museum display when the superintendent determines that the collection is necessary to the stated scientific or resource management goals of the institution or agency and that all applicable Federal and State permits have been acquired, and that the intended us of the specimens and their final disposal is in accordance with applicable law and Federal administrative policies" (36 CFR 2.5b). The regulations do not discriminate against for-profit or other corporate research firms provided that they are engaged in reputable scientific research activities, reflecting the reality that some of the very best science is practiced in private corporations while some of the most entrepreneurial research activities are carried out in universities and other academic institutions.

NPS policy documents also have recognized the importance of units of the National Park System to scientific research activities that might benefit human society as well as the natural environment. For example, Department of the Interior management policies provide that "[i]n recognition of the scientific value of parks as natural laboratories, investigators will be encouraged to use the parks for scientific studies when such use is consistent with NPS policies." The document *NPS 53* (on "Special Park Uses"; see Appendix 12, "Non-NPS Research") defines "acceptable" non-NPS studies as "those which are scientifically valid, consistent with specific park enabling legislation, and contribute to better understanding of park resources and environments or to the use of those resources and environments by people."

Permits are issued after a researcher has submitted a permit application that provides the information required by the park. The process helps ensure that the permit applicant discloses the information required to enable the park to determine that the proposed research activities are consistent with NPS.

There is an important distinction between "sale or commercial use" of natural products collected from national parks (which is prohibited under 36 CFR 2.1c(3)(5)) and the discovery of valuable useful applications from "research results" that can generate potential benefits (whether commercialized or not). This distinction is supported by developments in U.S. intellectual property rights laws and has been explicitly recognized at some national parks that host major research activities, such as Yellowstone. This distinction also has been upheld as valid by at least one federal court *(Edmonds Institute, et al. v. Babbitt, et al.).*

NPS research specimen collection permits operate in ways similar to the biological materials transfer licenses issued by the National Institutes of Health (NIH), which grant the permittee/licensee the right to use biological materials accessed from NIH. These arrangements are "licenses" (not "sales"), and the transfer of ownership is not necessarily involved (precisely because the operative instrument is a "license to use" and not a "sale").

Benefits-sharing

While the research specimen collection permits issued under 36 CFR 2.5 govern "access" to NPS biological resources for research purposes, section 205(d) of the National Parks Omnibus Management Act of 1998 specifically authorizes "negotiations with the research community and private industry for equitable, efficient benefits-sharing arrangements" involving units of the National Park System.

Prior to enactment of this law, NPS evaluated possible use of cooperative research and development agreements (CRADAs) as a potential "benefits-sharing" mechanism in circumstances involving joint research projects between units of the National Park System and visiting scientific researchers. A CRADA is defined by the Federal Technology Transfer Act (15 USC 3710a *et seq.*) as "any agreement between one or more Federal laboratories and one or more non-Federal parties under which the Government, through its laboratories, provides personnel, services, facilities, equipment or other resources with or without reimbursement (but not funds to non-Federal parties) and the non-Federal parties provide funds, personnel, services, facilities, equipment, or other resources toward the conduct of specified research or development efforts which are consistent with the mission of the laboratory..." (15 USC 3710a(d)).

CRADAs provide a framework specifically authorized by statute under which private companies and other research collaborators can contribute financial resources and expertise to a Federal laboratory facility to augment its own research in exchange for rights in any resulting useful or valuable discovery arising from the research (15 USC 3710a). CRADAs are authorized under the Federal Technology Transfer Act of 1986 and Executive Order 12591 (requiring federal agency heads to delegate authority to federal laboratories to enter into CRADAs with other federal laboratories, state and local governments, universities, and the private sector). The Department of the Interior's CRADA policy was outlined in May 1996 in a training handbook entitled *Technology Transfer: Marketing Our Products and Technologies.*

The statute defines the term "federal laboratory" to mean "a facility or group of facilities owned, leased, or otherwise used by a Federal agency, a substantial purpose of which is the performance of research, development, or engineering by employees of the Federal Government" (15 USC 3710a(e)). At least one federal court has concluded that national park units that host significant scientific research activities (such as Yellowstone) satisfy this statutory definition *(Edmonds Institute, et al. v. Babbitt, et al.).*

On 17 August 1997, Yellowstone National Park announced that it had negotiated a CRADA with a biotechnology research firm from San Diego, California, that already had a research specimen collection permit to collect microbial research specimens at the park. This CRADA is believed to be the first bioprospecting benefits-sharing agreement ever negotiated between a private-sector research firm and a unit of the National Park System that provides that a share of the economic and scientific research benefits will be reinvested directly in the park for resource conservation purposes.

The CRADA negotiated by Yellowstone was designed to operate in conjunction with the terms and conditions of the existing permit. The CRADA does not expand the scope of authorized research specimen sampling activities at the park, but now provides for the sharing of benefits (including payment of royalties and other contributions, training, and technology transfer to Yellowstone).

While the research specimen collection permits authorize access to and research on biological specimens acquired from a unit of the National Park System, CRADAs provide one possible benefits-sharing mechanism for those parks which satisfy the relevant "federal laboratory" statutory definition to use to recapture future revenues and other benefits.

NEPA

In accordance with an order issued by the U.S. District Court for the District of Columbia on 24 March 1999 *(Edmonds Institute, et al. v. Babbitt, et al.),* NPS is undertaking an analysis under the National Environmental Policy Act (NEPA) concerning the environmental impacts of negotiations with the research community and private industry for equitable, efficient benefits-sharing arrangements relating to research activities involving biological specimens acquired from units of the National Park System. The analysis will consider the environmental impacts of several potential benefits-sharing mechanisms that may be available to NPS (including but not limited to CRADAs) that would strengthen conservation of park resources through management of research activities involving specimens collected or derived from units of the National Park System.

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39 Getting the job done: protecting marine wilderness

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What is marine wilderness?

Anyone who has been on the ocean alone, out of sight of land, has experienced some sense of solitude and insignificance. "Vast" is a word seemingly invented for oceans, but is "vast" enough to make any part of the ocean a wilderness?

"Wilderness" is a difficult word to define. The grizzly bear cinematographer Doug Peacock says an area is wilderness if it contains something bigger and meaner than you are—something that can kill you (quoted in Foreman 2000). Roderick Nash, the wilderness historian, has noted that the word carries both positive and negative connotations: a wilderness can be at once inhospitable, alien, mysterious, and threatening, as well as beautiful, friendly, and capable of elevating and delighting us.

The Wilderness Act (P.L 88-577, passed in 1964) offers what seems to be the most widely accepted operational definition: "A wilderness, in contrast with those areas where man and his own works dominate the landscape, is hereby recognized as an area where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain."

Vast, inhospitable, beautiful, deserted, mysterious, threatening, and undoubtedly containing animals that can kill you. It would seem that the ocean could very appropriately be called "wilderness." Even the dictionary definitions mention the sea as one type of wilderness.

However, we know that not all ocean areas are "untrammeled by man." While it is not as easy to spot as a roadbed or a building, human effects on some ocean areas have been significant. Offshore oil and gas development, commercial fishing, and ocean outfalls for wastewater, for example, have all left their mark, especially in coastal ocean areas. Shipping and other vessel traffic plying designated shipping lanes and customary port-to-port routes are obvious examples of the human presence on the ocean. Boats grounding on coral reefs, and the tremendous damage they cause to reef ecosystems, could certainly be counted as "trammeling," as could smaller boats propeller-dredging in seagrass beds. The tons of debris that collect on the pristine beaches and coral reefs of the islands in the mid-Pacific are also telltale signs. While the ocean may contain wilderness, the dictionary may be overstating the case just a bit.

A close look at a few existing areas may help develop a better understanding on what should appropriately be called "marine wilderness." These areas may provide useful benchmarks against which other areas can be measured.

Glacier Bay National Park and Preserve. The National Park Service (NPS) even goes so far as to call this area a "marine wilderness" in its Web page description: "The marine wilderness of Glacier Bay National Park and Preserve provides opportunities for adventure, a living laboratory for observing the ebb and flow of glaciers, and a chance to study life as it returns in the wake of retreating ice. Amidst majestic scenery, Glacier Bay offers us now, and for all time, a connection to a powerful and wild landscape" (NPS 2001). Over 11,000 sq km were designated as wilderness by Congress in 1980 and thus made part of the National Wilderness Preservation System; approximately 215 sq km of this area is marine waters (Barr and Lindholm 2000). We can accept the NPS self-identification of Glacier Bay as "marine wilder-

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ness" as *prima facie* evidence that this area is a good benchmark for helping to define marine wilderness characteristics for other areas.

Tortugas Ecological Reserve, Florida Keys National Marine Sanctuary. Like NPS, the National Oceanic and Atmospheric Administration (NOAA) National Marine Sanctuary System has identified this area as possessing what we believe the qualities of marine—or what NOAA has called "ocean"—wilderness to be. On the sanctuary's Web page the area is described as follows:

> Because of its remote location 70 miles west of Key West and more than 140 miles from mainland Florida, the Tortugas region has the best water quality in the Sanctuary. Healthy baitfish populations support thriving seabird communities, including sooty and noddy terns, masked boobies and the only roosting population of magnificent frigate birds in the continental U.S.... The Tortugas reefs also boast the healthiest coral in the region. In the area dubbed "Sherwood Forest," coral cover often exceeds 30%, compared to an average of 10% elsewhere in the Florida Keys. The well-developed reef forms a false bottom, interspersed with gorgonian-forests, sponges, and black corals.... Threats to the Tortugas resources exist and are on the increase. Commercial and recreational fishing pressure has reduced the average size of black grouper in the Tortugas from 22.5 lbs. to 9 lbs. The Sanctuary has prohibited anchoring by freighters on the lush reefs of Tortugas Bank, but other parts of the region are still threatened by damage from anchors weighing several tons (NOAA 2001a).

Outstanding resources, identified threats, remote, strikingly beautiful seascapes, and you probably wouldn't have to poke around much to find something that could kill you—this is almost certainly another useful benchmark area in the effort to better define marine wilderness.

Northwest Hawaiian Islands Coral Reef Ecosystem Reserve. This is the third likely benchmark site, designated by Executive Order (#13178) issued December 2000. It is a massive 340,000 sq km, the second-largest marine protected area in the world after the Great Barrier Reef Marine Park. As summarized on its Web page (NOAA 2001b) the characteristics of the site are very similar to those of the Florida Keys sanctuary. The site is also significantly threatened for reasons related to geography and physical oceanography. Because of its location in the Central Pacific gyre, nearly every piece of cast-off fishing net, cargo net, plastic, or other debris seems to collect on some of these atolls. Millions of pounds of debris have been removed, but this treated the outward symptom but not the root cause. Certainly this is not a problem throughout the reserve, but it is very much a problem in certain locations.

Remote, nationally significant resources, important habitat for endangered species (the entire population of Hawaiian monk seals are found in this region), contains 65% of all coral reefs in U.S. waters, has significance to cultural heritage, and again, it wouldn't take long to find something that could inflict serious damage. This constitutes another likely benchmark site for marine wilderness.

What qualities make these benchmarks for marine wilderness?

Reaching consensus on calling something "wilderness" is almost never without controversy. It is only slightly more straightforward on land, with almost thirty years of history. Given the considerable connectedness of marine ecosystems, the often inadequate information available for these areas, and the importance of the ocean's most productive and biologically diverse areas to commercial interests, calling something "marine wilderness" is likely to be hotly debated.

Some of the same attributes that make a place "wilderness" on land are those that could be put forward as defining marine wilderness. Clearly, the Wilderness Act cornerstone of "untrammeled by man" must play a role. In each of the marine benchmark examples, human influence on the ecosystem is less obvious than in other areas of the ocean, except perhaps in a few areas of the Northwest Hawaiian Islands where marine debris is a chronic problem. Even in this example, however, the debris that collects in these places generally has been transported there over great distances by ocean currents, not dumped there directly. Perhaps this "long-distance trammeling" must be evaluated differently than the building of a road; it is more appropriately compared with atmospheric deposition of contaminants in terrestrial wilderness areas.

Given the global nature of human influence over ecosystems, finding anyplace that is truly "untrammeled" requires the use of a relative scale of measurement. The history of the wilderness movement includes some very acrimonious debates over the question of whether wilderness needs to be "pristine" (a position viewed by some as a way to avoid designating wilderness because there are few if any pristine environments to be found anymore). Accepting such a relative scale *a priori* may avoid the controversy. The challenge is to determine the lower end of the scale for the "untrammeled" character of any marine area to be sure we are not being overly lenient in its application.

Perhaps one of the ways to approach this is to seek out areas that are as free of human influences as possible, and where impacts can be limited or controlled through aggressive protection. The work in Glacier Bay National Park and Preserve to phase out commercial fishing, severely limit the air- and water-quality impacts from cruise ships, and establish areas where motorized vessels are prohibited, as well as the clean-up and source-reduction efforts to address marine debris in the Northwest Hawaiian Islands, are examples of efforts to restore these areas to an untrammeled state. For marine wilderness, it may be both how pristine the area is and whether the agency managers have the technical ability and political will to protect its wilderness character.

Another obvious characteristic, probably part of the reason any of these sites might be called untrammeled, is remoteness. Each is far enough away from population centers so that the effects of humans are limited, again with the exception of marine debris in Northwest Hawaiian Islands. Geography seems to provide the only partial refuge from "civilizing" influences.

These areas also contain fine examples of particular habitats, such as the coral reefs at Tortugas and Northwest Hawaiian Islands and the inshore marine areas of the Gulf of Alaska at Glacier Bay. Having these ecosystem exemplars provides opportunities for research needed to understand and better manage marine protected areas elsewhere.

Being at sea is uniformly dangerous. Many lives have been lost as the result of the fury of the ocean environment, considerably more than in any wilderness on land. Recently it has been determined that the most dangerous occupation in the USA is that of commercial fisherman, and there are many monuments in coastal communities that mourn such losses. There are also some fearsome creatures in the sea that, when encountered, can equal or exceed the thrill and sense of dread one feels when confronted with a grizzly bear.

Individuals, with some preparation and dogged determination, can and have taken up residence in terrestrial wilderness. We have not yet figured out a way to colonize the ocean, although this form of pioneering is the fodder of many science fiction novels. For marine wilderness, the language of the Wilderness Act that holds that wilderness is a place "where man himself is a visitor who does not remain" perhaps might be measured in terms of how frequently the area is visited or how consequential those visits are with respect to the quality of the wilderness experience. For some areas like Glacier Bay, visited by a considerable number of cruise ships each season, the critical question might be whether the wilderness experience is degraded by this visitation.

The ultimate question regarding marine wilderness is whether the future of these areas is more dominated by natural processes or not, and what level of management is needed to sustain the areas' wilderness character. If we have to work too hard to keep or make a place wilderness, it probably isn't. While we strive for a criteria-based definition, perhaps we need a gestalt approach: we may not know how to define wilderness, but we know it when we see it.

How do we protect it?

Marine wilderness, as a relatively recent expansion of the concept, can benefit from the nearly thirty-year experience of terrestrial wilderness managers. While there has been some concern expressed about the progress of wilderness management within the wilderness community (Sellars 2000), the responsible agencies, especially NPS (see particularly Director's Order #41), have given considerable thought to how we effectively protect wilderness. In the process of developing first principles for marine wilderness, what has been learned is extremely useful.

Surveying the body of information on the management of wilderness, a number of elements rise to the surface that may help to answer the "how to" question for marine wilderness. While the fit may not be perfect, the concepts are instructive.

Minimum requirement analysis. Under provisions of the Wilderness Act, agencies are required to conduct an analysis of whether a given activity is appropriate and if so, how it can be done with minimum impact on the wilderness qualities of the area. Guidance has been provided on how this determination is conducted, and a "Minimum Requirement Decision Guide" developed by Arthur Carhart National Wilderness Training Center is available on its Web page (ACNWTC 2001). Clearly, activities, including management actions, can significantly affect the wilderness experience, and some similar analysis would be appropriate for marine wilderness.

Backcountry access permitting. One way that impacts on wilderness qualities are minimized is to limit human use of the area. National parks require special permits in very sensitive areas to limit access. While limiting access in open ocean areas presents some challenges, the concept is already being tried in the Tortugas Ecological Reserve.

Roadless policy. With some limited exceptions, no roads are permitted in terrestrial wilderness, and motorized vehicles are excluded. Clearly, there are no roads in the ocean, but there are designated shipping lanes and customary routes between ports that vessels are more likely to use on a regular basis, as well as certain offshore areas where vessels often travel to engage in some activity (such as fishing). The message here might be that marine wilderness should not include designated shipping lanes, customary inter-port routes, or areas where vessels are likely to congregate. The use of motorized vessels for access to many offshore areas may be unavoidable, but the way to provide safe access might be determined through minimum requirement analysis. For some inshore areas, vessel access might reasonably be limited to canoes and kayaks, as in wilderness areas in Glacier Bay National Park and Preserve.

Limited accommodation of rights-based prior uses. The Wilderness Act and various implementing policies afford a special status to rights-based prior uses such as mining, grazing, and, in places, motorized vessel and aircraft use, but within strict limits.

While private ownership of ocean waters and the seabed is very limited, leasing for hard minerals and oil and gas extraction are reasonably common in coastal waters, and aquaculture facilities involve exclusive-use issues. Aquaculture activity may be somewhat analogous to grazing, and has been equally controversial. Oil and gas, hard minerals, sand and gravel and (perhaps soon) gas hydrate mining all could be construed as "mining activities" under the Wilderness Act. Policies mandating acquisition of mining rights for marine wilderness could provide an interesting strategy for marine minerals and hydrocarbon leases. At least in the National Marine Sanctuary Act , a mechanism exists that requires certification of existing leases when a site is designated, and can be conditioned if necessary and appropriate (but usually boundaries are crafted to avoid including such existing uses). The trick here will be to provide reasonable accommodation, when it is appropriate, without "giving away the farm" in terms of preserving wilderness values.

Under this heading, there is a special case of "rights-based prior uses" that will likely emerge in discussions of marine wilderness. This has to do with the issue of commercial fishing. Under the Wilderness Act, all commercial activities are prohibited, except for those that are needed to enhance appropriate recreational use. Presuming that the model of banning commercial activities from the Wilderness Act is carried forward into marine wilderness, commercial fishing would be prohibited. The ocean, seabed, subsoil, and the living and non-living resources there are owned in common by the people of the USA, and the agencies act as stewards for the owners. Many fishermen, however, believe they have ownership rights over their fishing grounds, and maintain that if you take this "right" away, they must be compensated (See Barr, this volume). While challenging precedents may have been made in "compensating" fishermen for displacement from wilderness areas of Glacier Bay, this approach is not economically viable in larger areas with more extensive fisheries, and may greatly impede progress generally with regard to preserving marine wilderness.

Other issues. There are several other issues related to terrestrial wilderness management that could also apply to the marine realm, including the need for wilderness plans, greater accountability among wilderness managers (Sellars 2000), wilderness training, and a strong commitment to effective enforcement. These tools and strategies provide a good start to developing effective protection of marine wilderness. Undoubtedly others will be needed, but utilizing what is already available helps us avoid having to reinvent the good existing tools.

Concluding observations

Marine protected area managers have much to learn from terrestrial wilderness managers—and the latter might also learn a thing or two in this cross-talk. Most wilderness values are common to both land and sea. The Wilderness Act (appropriately amended to include agencies such as NOAA with marine preservation authority) would provide a solid foundation for identifying and designating marine wilderness. In addition, expanding our collective perception of wilderness to include marine wilderness would broaden the base of public support for wilderness generally, and provide us with additional opportunities to do the job effectively.

Perhaps a more critical issue is whether we need marine wilderness. Is this something that is significantly different from elements of existing marine protected area programs? Looking again to existing land-based wilderness for guidance, these areas can provide considerably more to the quality of our lives than traditional resource protection programs. Americans have a heritage of exploration and a collective drive toward wild areas. Wilderness is part of who we are as a people. Oceans are our last true wilderness: "inhospitable, alien, mysterious, and threatening" but also "beautiful, friendly, and capable of elevating and delighting us" as wilderness is so eloquently, albeit unexpectedly, described in dictionaries. Wilderness, novelist Wallace Stegner has said, "is part of the geography of hope." Marine wilderness seems to be unquestionably part of that geography.

The views expressed herein are those of the author and are not meant to reflect in any way policies, positions or views of the Department of Commerce, NOAA, or any of its sub-agencies.

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40 Geoindicators: a tool for monitoring the ecosystem and understanding the resources

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"Geoindicators" is a coined term for a class of geologic environmental indicators recently developed as a tool to assess rapid change in the environment and provide some measure of ecological health by examining the abiotic component of ecosystems. Twenty-seven indicators examine the near-surface geologic, hydrologic, and atmospheric parameters that are likely to change in the period of a human life span. Geoindicators look at both human and natural components of change in the ecosystem, identifying critical areas and measuring them independently. The International Union of Geological Sciences developed the geoindicators concept for environmental planning in the mid-1990s through its geoindicators working group (Antony Berger, chairperson).

The National Park Service (NPS) has adopted the geoindicators tool to implement portions of its strategic plan and provide improved science-based information to park managers. In recent decades, increasing pressures on park resources have created a need for active management of park ecosystems. In 1997, Richard Sellars' book *Preserving Nature in the National Parks*, along with earlier reviews by the Park Service and external organizations, showed that often this work was being done with ambivalence about the role of science in park management and decision making (Sellars 1997). The Park Service now recognizes that active management requires scientific knowledge and understanding of natural systems.

However, most parks, even those with significant geologic resources, don't have geologists on staff or in their regional offices to call on for expertise. The geoindicators checklist was designed to enable planning teams make science-based assessments of geologic conditions. Geologists designed geoindicators for non-geologists and geologists alike.

As a land manager, NPS is interested in environmental assessments, particularly those that can identify rapidly changing conditions. Most park resource managers are familiar with the indicators and monitoring methods used to determine change in the biological components of the ecosystem. With geoindicators, park managers will now have access to the same criteria that geologists would use to help determine the health of the ecosystem and guide management decisions.

The geoindicators tool begins with a checklist that enables parks to identify geologic and hydrologic processes important for evaluating the state of the environment, ecosystem change, and how humans are affecting natural systems. The easy-to-use checklist includes twenty-seven indicators selected for their ecological importance:

1. Coral chemistry and growth patterns
2. Desert surface crusts and fissures
3. Dune formation and reactivation
4. Dust storm magnitude, duration, and frequency
5. Frozen ground activity

From **Crossing Boundaries in Park Management: Proceedings of the 11th Conference on Research and Resource Management in Parks and on Public Lands,** edited by David Harmon (Hancock, Michigan: The George Wright Society, 2001).

6. Glacier fluctuations
7. Groundwater quality
8. Groundwater chemistry in the unsaturated zone
9. Groundwater level
10. Karst activity
11. Lake levels and salinity
12. Relative sea level
13. Sediment sequence and composition
14. Seismicity
15. Shoreline position (Figure 40.1)
16. Slope failure (landslides; Figure 40.1)
17. Soil and sediment erosion
18. Soil quality
19. Streamflow
20. Stream channel morphology (Figure 40.2)
21. Stream sediment storage and load
22. Subsurface temperature regime
23. Surface displacement
24. Surface water quality
25. Volcanic unrest
26. Wetlands extent, structure, and hydrology (Figure 40.2)
27. Wind erosion

The geoindicators tool goes well beyond identifying topical areas in geology; it provides sufficient information to assess each indicator based on ten separate criteria. With the tool, the user can determine the significance of each indicator for specific park ecosystems. In addition, the criteria help define parameters for monitoring each indicator.

1. *Significance.* Why is it important to monitor this indicator?
2. *Human-caused or natural change?* Can this geoindicator be used to distinguish natural from human-caused change, and, if so, how?
3. *Environment where applicable.* In what general landscape settings would this geoindicator be used?
4. *Spatial scale.* At what scale would this geoindicator normally be monitored in the field?
5. *Types of monitoring sites.* Where specifically should the geoindicator be measured?
6. *Method of measurement.* How is this indicator measured in the field?
7. *Frequency of measurement.* How often should this geoindicator be measured so as to establish a time series and baseline trend?
8. *Limitations of data and monitoring.* What important difficulties are there in acquiring field and laboratory data?
9. *Application to past and future.* How can this geoindicator be applied to paleoenvironmental analysis?
10. *Possible thresholds.* What thresholds and limits cannot be exceeded without drastic environmental change or threats to human health and biodiversity?

The geoindicators help answer NPS resource management questions about what is happening to the environment, why it is happening, and whether it is significant. They can also be used to establish baseline conditions and trends so that human-induced changes can be identified.

A resource management team can begin to use the geoindicator checklist by implementing the simplified approach described below. It is recommended that a geologist, hydrologist, or soils scientist is included as a part of the park team.

Figure 40.1. Some geoindicators. Top: Shoreline position: offset shoreline due to human-made jetties. Bottom: Slope failure: environmental factors exceeding surface material strength.

Figure 40.2. Some further geoindicators. Top: Stream morphology: dynamics of the river channels. Bottom: Wetlands extent, structure, and hydrology.

Step 1. Use the checklist of 27 indicators to identify all geologic processes that occur in park ecosystems.
Step 2. Screen the list further to identify those indicators which are of greatest importance—those serving as drivers in ecosystem function—and those being influenced by human activity.
Step 3. Apply the ten assessment criteria for each of the indicators selected in Step 2.

After going through this process, the assessment team can make recommendations for research, identify gaps in the data, recommend a monitoring plan, and identify preliminary monitoring protocols.

The geoindicator checklist can help to focus our thinking about landscape management. However, it only reaches its full potential when used in concert with other scientific disciplines. Geology and the other physical sciences contribute important information to our understanding of ecosystem function, but information from social and biological sciences is also needed. The triangular diagram (Figure 40.3) illustrates conceptually how the basic sciences of ecosystem study contribute to our understanding and development of an ecosystem model.

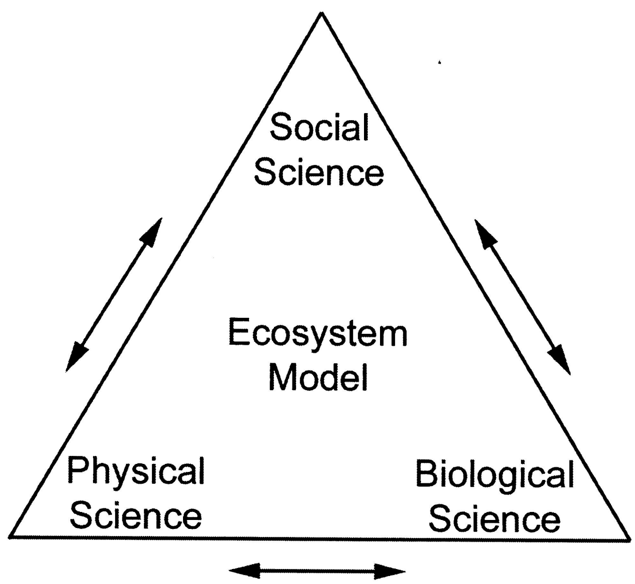

Figure 40.3. The basis of an ecosystem model.

Understanding ecosystems requires not only knowledge of the component parts and their interactions, but their natural cycles and variability as well. In the last few decades, we have come to realize that change in an ecosystem is normal, naturally occurring, and desirable. Steady-state conditions over time are not generally the norm. This concept is important for our understanding of the interaction of human influences and natural processes. We perceive that the human component of change in the ecosystem is expanding disproportionately and often at the expense of abiotic and other biotic components. But measuring stress at the interface between humans and the environment requires scientific tools that can resolve naturally occurring change from human-induced change. The geoindicators tool can contribute to sustainable park management by providing information on both natural conditions and the effects of human actions.

In the NPS, geoindicators have been integrated into several projects to provide science-based information for resource management. The year 2000 was the pilot year for the NPS Strategic Plan Goal Ib4, the identification of human influences on geologic processes. This knowledge-based goal uses the combined expertise of park personnel and geologists to identify natural earth-system processes that are being influenced by humans. In September 2000, the first scoping meeting for this goal was conducted at Craters of the Moon National Monument involving staff from the park, the NPS Geologic Resources Division, and the U.S. Geological Survey. The geoindicator checklist was a focal point of the scoping meeting, which identified critical geological components of the park ecosystem for long-term ecological monitoring and research. Over the next five years, parks throughout the National Park System will be using geoindicators to conduct ecological assessments, evaluate monitoring needs, and meet strategic goals.

Geoindicators are also being integrated into the Vital Signs Monitoring Program for NPS Strategic Plan Goal Ib3 to identify geologic "vital signs" of ecosystem condition in the 32 monitoring networks and in individual park units. In April 2000, the concept was introduced as an assessment tool at the Northeast Barrier Network's vital signs scoping meeting. The checklist and criteria were used during the meeting to evaluate options for monitoring, and shoreline position was selected as a critical ecological indicator.

Recently, the long-term monitoring program of NPS initiated development of a handbook for natural resource monitoring. The NPS Geologic Resources Division drafted a chapter on geologic resource monitoring that includes the geoindicator concept (NPS 2001).

In addition to the existing applications for geoindicators, we believe the checklist can provide other benefits to the Park Service. The NPS planning process in general may benefit by considering geoindicators, but the General Management Plan (GMP) process and, specifically, the visitor experience and resource protection element, need geoindicators. Geologic information is important to consider for evaluations of visitor experience, safety, and protection. Since the geoindicator concept addresses human-induced change to geologic processes and features, its use can make it easy for parks and planning teams to consider the effects of development and visitor use on natural systems. The geoindicators checklist could also be adapted to help in identifying resource management needs and providing information for new funding proposals.

Ever since we first viewed Earth from space in the late 1960s, we have had a clear image of the boundaries of our ecosystems. Since then, there has been an increasing public expectation, nationally and internationally, that scientists would eventually gain an understanding our global ecology and provide for the preservation of the environment in which we live. There are further expectations that national parks protect the best examples of pristine conditions and therefore, may provide a baseline for ecosystem comparisons. By gathering long-term data on geoindicators in parks, we hope to gain a better understanding of geology's role in the ecosystem and provide information that will contribute to the preservation of healthy ecosystems.

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41 Implementation of the principles for environmental management in the West: the Enlibra Process and reclamation of the Atlas Uranium Mill tailings

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The Enlibra Process

In 1999, the Western Governors' Association adopted a resolution titled "The Principles of Environmental Management in the West" (Western Governors' Association 1999). The purpose of this resolution was to launch a new process to address increasingly complex environmental issues facing the western USA and the polarization that oftentimes accompanies these issues. The process was termed "Enlibra," emphasizing a balanced, open, and inclusive approach to environmental and natural resources stewardship. As spelled out in the resolution, the principles of the Enlibra doctrine include the following:

- National standards, neighborhood solutions—assign responsibilities at the right level;
- Collaboration, not polarization—use collaborative processes to break down barriers and find solutions;
- Reward results, not programs—move to a performance-based system;
- Science for facts, process for priorities—separate subjective choices from objective data-gathering;
- Markets before mandates—pursue economic incentives whenever appropriate;
- Change a heart, change a nation—environmental understanding is crucial;
- Recognition of benefits and costs—make sure all decisions affecting infrastructure, development, and environment are fully informed; and
- Solutions transcend political boundaries—use appropriate geographic boundaries for environmental problems.

Since 1999, the Enlibra process has been applied to a number of environmental and natural resource issues facing the West. Examples include the Western Regional Air Partnership, the Wyoming Open Lands Initiative, trail and recreational access in Alaska, the Oregon Coastal Salmon Restoration Initiative, desert tortoise habitat conservation planning, Texas regional water planning, and a strategy to address water pollution from animal feeding operations in Utah. More information on Enlibra and its application to these and other issues may be obtained at the Western Governors' Association Web site (WGA 2001).

Enlibra and reclamation of the Atlas Uranium Mill tailings

In late 1999, the Utah Department of Environmental Quality and Grand County, Utah, decided to engage the Enlibra process in order to foster a decision with respect to final reclamation of the Atlas Uranium Mill tailings located three miles northwest of Moab, Utah. The site is also immediately adjacent to the Colorado River and Arches National Park, and is upstream of Canyonlands National Park and Glen Canyon National Recreation Area.

Atlas Minerals Corporation operated a uranium mill at this site from 1956 to 1984. The mill generated 10.5 million tons of tailings, which were deposited in an

From **Crossing Boundaries in Park Management: Proceedings of the 11th Conference on Research and Resource Management in Parks and on Public Lands,** edited by David Harmon (Hancock, Michigan: The George Wright Society, 2001).

unlined disposal facility southwest of the confluence of Moab Wash and the Colorado River. The tailings pile covers approximately 130 acres and reaches a height of approximately 100 ft.

Following closure of the mill, the Nuclear Regulatory Commission (NRC) began an assessment of how the site should be stabilized and reclaimed. A final Environmental Impact Statement (EIS) under the National Environmental Policy Act (NEPA) was completed in 1999, and the preferred alternative called for stabilization and reclamation of the pile in its current location. During the EIS process, the National Park Service (NPS) raised concerns associated with potential catastrophic failure of the pile (due to flooding or an earthquake), water quality impacts (both to groundwater and surface water), related effects on endangered fish in the Colorado River, and air quality impacts (particularly the release of fugitive dust and radon). Of particular concern to NPS were elevated concentrations of ammonia, barium, manganese, molybdenum, vanadium, and gross alpha in groundwater under the pile, and associated impacts to the Colorado River (particularly to the endangered Colorado pikeminnow, which spawns in backwater areas of the river immediately adjacent to and down-gradient of the pile).

NPS raised these concerns in its review of various technical reports and NEPA documents. NPS also continued to stress that all other uranium tailings piles along the Colorado River, under the control of the U.S. Department of Energy (DOE), had been relocated away from the river to engineered disposal sites overlying impermeable materials. It should also be noted that in 1998 Atlas Minerals Corporation filed for bankruptcy. PricewaterhouseCoopers LLP was ultimately designated as trustee for the site.

In October 1999, the state of Utah and Grand County engaged the Enlibra process to provide a mechanism to enhance information exchange and collaboration and to attempt to work out a solution for this long-standing issue. As a first step, a stakeholder meeting was convened to begin a dialogue on the issue. Attendees included representatives of the Utah Department of Environmental Quality (UT-DEQ), Grand County, the city of Moab, NRC, U.S. Environmental Protection Agency (EPA), DOE, U.S. Fish and Wildlife Service (USFWS), NPS, the Office of the Solicitor in the U.S. Department of the Interior, the Utah Congressional delegation, the Utah State Legislature, PricewaterhouseCoopers, the Grand Canyon Trust, and private citizens. Since there was ongoing litigation among some of the stakeholders in regard to this issue, an agreement was reached at the outset that dialogue at stakeholder meetings would be informal and not part of "discovery" in any legal proceeding.

In a subsequent meeting in January 2000, the stakeholders group established a groundwater subcommittee since it was realized that whether the tailings remain in place or are relocated, degraded groundwater at the site must be cleaned up. The subcommittee was charged with enhancing information-sharing and exchange and working directly with PricewaterhouseCoopers to develop a better understanding of groundwater conditions at the site and to evaluate various remediation measures. Members of the subcommittee included UT-DEQ, Grand County, EPA, DOE, USFWS, NPS, PricewaterhouseCoopers, and the Grand Canyon Trust. NRC opted not to be a member since it did not believe it was appropriate for NRC to work with PricewaterhouseCoopers in developing remediation strategies for addressing groundwater contamination at the site. NPS chairs the subcommittee.

Since January 2000, the subcommittee has evaluated a dewatering plan for the tailings and reviewed a geohydrology and geochemical characterization plan for the site. The subcommittee has also assessed various measures that could be carried out on an interim basis to address elevated levels of ammonia detected in the Colorado River—levels that are lethal to endangered fish in backwater areas adjacent to the pile (USGS 2000). It should be emphasized that the focus of the subcommittee has been on information-sharing and exchange, not on forging consensus positions on various groundwater issues. Future work of the subcommittee will include further assessments of interim measures to control ammonia in the Colorado River and review of a groundwater corrective action plan for the site.

Another recent development was the passage of the 2001 National Defense Authorization Act (Public Law 106-398) in October 2000. This law mandates the transfer of title to the site to DOE no later than October 2001, provides an innovative mechanism to fund final reclamation of the pile, directs DOE to develop a remediation plan (including groundwater restoration) for the site, and directs the National Academy of Sciences (NAS) to evaluate and make recommendations with respect to various remediation alternatives. This law also encourages relocation of the pile to a site in Utah off the floodplain of the Colorado River. As such, the groundwater subcommittee plans to review DOE's remediation plan and possibly assist NAS in its evaluations as well.

Observations on Enlibra

As indicated above, application of the Enlibra process to reclamation of the Atlas Uranium Mill tailings situation is currently underway. Based on experience to date, the following observations on the Enlibra process are offered:

1. The Enlibra process is capable of providing a forum for effective collaboration, communication, and cooperation;
2. The Enlibra process is not a substitute for standard regulatory processes (e.g., consultation under Section 7 of the Endangered Species Act);
3. Since non-governmental parties are oftentimes involved, care should be taken to assure that the requirements of the Federal Advisory Committee Act are adhered to;
4. It would appear that the Enlibra process has a better probability for success when issues are of limited scope and there are a manageable number of stakeholders involved; and
5. The Enlibra process appears to provide a mechanism to assist NPS in addressing significant environmental and natural resource issues facing units of the National Park System (e.g., energy development near parks, fire management in the urban interface area, and recreational uses in parks).

Conclusions and recommendations

Based on the Atlas Uranium Mill tailings experience and other applications to date, the Enlibra process, as developed and espoused by the Western Governors' Association, provides an approach to address and (one hopes) resolve environmental and natural resource issues facing the West, including a number of issues facing NPS. The collaborative and cooperative mechanisms established under the Enlibra process (e.g., stakeholder forums) provide constructive, working venues in this regard. Further, while the potential for the Enlibra process to find solutions to highly contentious environmental and natural resource issues is promising, it should be recognized that the Enlibra process faces many challenges in light of the complexities, polarization, and litigation oftentimes associated with these issues. It is recommended that, on a case-by-case basis, NPS consider the utilization of the Enlibra process to address environmental and natural resource issues of concern and that the agency also take advantage of opportunities to participate in the Enlibra process in cases where environmental and natural resource issues facing units of the National Park System are to be addressed.

Note: Opinions expressed in this paper represent the opinions of the author and do not necessarily represent the position of the National Park Service or the U.S. Department of the Interior.

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42 Inclusion in NPS management at Grand Canyon: tribal involvement and integration

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Grand Canyon National Park has a long history of relationships with Indian tribes. Unfortunately, much of the history reflects the history of the U.S. government when it comes to tribal relations. In the last decade, the National Park Service (NPS) at Grand Canyon has made a concerted effort to change the legacy we have inherited regarding resource management and relationships with our tribal neighbors. Specific negotiations with the Hualapai and Havasupai tribes relative to management alternatives and resource issues provides opportunities to examine ways in which consultation and coordination between the sovereign nations can be achieved for the betterment of resource management in the greater Grand Canyon region. This integration has afforded NPS managers an avenue for meaningful involvement of our neighboring tribes in park management. Concerns over development, conflicting management strategies, natural and cultural resources, economic development, and the preservation of sovereignty are core issues of our ongoing process. Successes have been hard to achieve, although perseverance has shown that success is both positive and possible.

Grand Canyon National Park is located in northern Arizona, the most prominent geologic province of the Colorado Plateau. Just as Euro-Americans were overwhelmed with its power and beauty, Native Americans saw the Grand Canyon as a special place, one that is often intertwined with the origin histories of the native peoples themselves. Nine separate contemporary tribal governments ascribe some affiliation to the Grand Canyon, one of them coming forward only this past year indicating that they have a connection to the place. The Havasupai, Hopi, Hualapai, Kaibab Paiute, San Juan Southern Paiute, Navajo, Paiute Indian Tribe of Utah, Zuni, and, most recently, the White Mountain Apache all have some history that ties their people to the Grand Canyon.

As the political boundaries of Indian reservations and national parks were created, many of the tribes' ancestral affiliations were overlooked by federal managers. At Grand Canyon, the last ten years have seen a dedication to actively working with our neighboring tribes and including them in park management decisions. The relationship Grand Canyon has with the Havasupai and Hualapai are among the most complicated and vexing relationships the NPS has, largely due to conflicting legislation and diametrically opposed management concerns.

The Havasupai are one of the 14 bands of Pai who have historically lived in the southwestern United Sates. They see themselves as the guardians of the Grand Canyon, and their responsibilities for guardianship extend far beyond their canyon home. The Havasupai Tribe and the park have a history defined by legislation and legal battles—most importantly the 1975 Grand Canyon Enlargement Act. In that act, not only was the park expanded to its present 1.2 million acres, but the Havasupai Indian Reservation was expanded by 185,000 acres of rim land, and the tribe was afforded use of an additional 95,300 acres of Grand Canyon National Park for hunting and gathering (i.e., traditional activities). The act was controversial; most notable was the opposition of the Sierra Club against the expanded reservation and use of lands within the park for traditional subsistence activities. One provision of the act that has complicated the park's relationship with the tribe was the requirement that the tribe

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give up all claims to Supai Camp. Supai Camp is a 160-acre parcel of land to the west of Grand Canyon Village on the South Rim of the canyon. This small area was set aside in the 1930s by NPS for the development of an Indian Camp. NPS built a number of cabins on the site and moved local Havasupai families into the cabins and out of their traditional dwellings. The superintendent responsible for the camp, Minor Tillotsen, planned a large community at Supai Camp, consisting of upwards of 36 cabins and common facilities. Although the full plan never materialized, five cabins still remain at the camp, along with a "washeteria" and a community building now used as a home.

The history of the Havasupai people and NPS is dotted with instances in which the Park Service attempted to move the Havasupai off the South Rim, preferring they remain on the small (originally slightly over 500-acre) reservation in Havasu Canyon. Many ranger reports and superintendent annual reports can be found in the files that tell of the attempts of park rangers to burn the Havasupai camps each time the residents went back to Havasu as part of their seasonal round of subsistence activities. This history is very real and very present to today's Havasupai, with many tribal members remembering the stories told by their parents and grandparents of the way that NPS treated them. These stories, and the retelling of them to each successive generation, have provided a folk history that has been hard to live beyond. However, Grand Canyon National Park has been trying.

Over the last two years, the park and the Havasupai Tribe have been engaged in a program to allow a mechanism for the tribe to use and occupy Supai Camp through a special memorandum of understanding. This would seem like a simple document to develop, but because of the 1975 Enlargement Act and the NPS history with the Havasupai people, it has been very difficult to negotiate. NPS is prohibited from giving away any land under its jurisdiction; only Congress can do that. NPS does not have the ability to lease land either. Yet, since the 1930s NPS has allowed the Havasupai to occupy Supai Camp, living primarily in the five cabins originally built for tribal use. After the 1975 Enlargement Act, the park entered into five-year "special use permits" with the tribe for its continued use of the area. The five-year agreements did not provide the security the tribe needed to procure funds for improvements to the camp, an action the tribe wanted to do to improve the living conditions for its members, even though the majority of the buildings were owned by the NPS. In addition to the mistrust of the five-year agreements, park managers in the early 1980s attempted to shut down the camp through an Arizona Department of Health action brought on by the opening of a new sewage plant. The new plant did not serve the camp, and, once it became operational, the camp would be without water and sewer facilities, thereby triggering a state closure.

The majority of the cabins at Supai Camp were built and are still owned by NPS. Up until sometime in the mid-1980s, the residents were charged rent for the units, ostensibly to help pay for upkeep and maintenance. No records of any maintenance on any of the cabins could be found in park files, and the charging of rent was discontinued then. The tribe, however, was very interested in upgrading the cabins, but fell into the same trap of not being able to procure funds to upgrade NPS-owned buildings. Every time they requested funds from the Bureau of Indian Affairs and other granting entities, they were denied this much-needed financial assistance because the tribe did not own the cabins, nor were they on tribal land. With the five-year agreements, there was no long-term commitment for their use by the tribe, and NPS could terminate their use of the camp at any time.

The tribe repeatedly came to NPS asking for a different type of agreement, one that would allow the tribe long-term use and occupancy of the camp. In early 2001, the park and the Havasupai Tribe signed a 25-year memorandum of understanding (MOU) for the use and occupancy of Supai Camp. The agreement could be challenged, as there is no legal precedence for it. However, given our responsibilities to the Havasupai through park legislation and a host of federal laws, executive orders, and agency policies, an agreement with the tribe for truly long-term use of Supai Camp was necessary. Even with the signed agreement, residents of the camp are suspicious of the NPS and park managers. As we discuss the possibilities of rehabilitating and upgrading the cabins, residents express reluctance at moving, even temporarily, from the camp. We have a long way to go in establishing trust with the tribe and its members. One hopes that this agreement and the improvements already made at the camp will move us along that path.

Our relationship with the Hualapai is equally complicated, albeit for slightly different reasons. When Grand Canyon National Park was established, the Hualapai Reservation was over 30 years old. The reservation boundaries were established in 1883, with the description of the reservation boundary stating that the north boundary was along the south shore of the Colorado River. Verbal descriptions referred to the reservation as being "devoid of water," suggesting that the Colorado was not within the reservation boundary. From a legal perspective, the federal government defined the reservation as being excluded from the park, with their boundaries adjoining for 108 miles along the Colorado. From a cultural and historic perspective, the Hualapai people believe that the Colorado River forms the backbone *(Hakataya)* of their lifeline and the center of the river is within their traditional lands. They do not agree with the federal government's interpretation of the boundary and have challenged the Department of the Interior's solicitor's opinion on numerous occasions.

The park and the Hualapai Tribe have agreed to disagree, a situation that has allowed the parties to begin working cooperatively in the area where the boundaries between the two entities are unclear. Rather than discuss the boundary "dispute," we now refer to the "area of cooperation" (AOC). Beginning in the summer of 1999, Grand Canyon National Park and Lake Mead National Recreation Area, representing the NPS, began negotiations with the Hualapai Tribe to begin a formal, cooperative, working relationship. After four meetings (and one recall election involving the tribal chairperson, vice-chairperson, and one council member), the three parties signed an "Agreement of Purpose" whereby we specify our roles and responsibilities of our relationship. In particular, the agreement acknowledges that all parties need to:

- Develop procedures to resolve disputes which may arise because of their geographic relationship;
- Look for opportunities for cooperation and sharing of resources; and
- Develop management options all parties can agree to.

The agreement set forth the principles and processes used to guide the negotiations leading to the development of a MOU between the parties.

On February 10, 2000, the parties signed the Agreement of Purpose, thereby formalizing the negotiation process. Over the next seven months, the parties worked on the MOU, achieving success in September 2000. The MOU formalizes a government-to-government partnership, sets forth a process to identify issues of mutual concern, develops mutual management options, encourages collaboration and creative problem solving, and provides a mechanism for implementation of agreed-upon management and operational protocols. While the MOU acknowledges the differing interpretations on the boundary, it provides a mechanism for specific actions for collaborative approaches in the AOC.

One important aspect of the MOU is the vision statement. Without shared vision, success will be difficult to achieve. All of the parties acknowledge a vision for the Colorado River and the Grand Canyon as a place of cultural significance, a place to be protected. Additionally, the parties recognize the tribe's need to promote economic development and tourism within the AOC. These two notions could be incompatible, but it is our hope that through our working partnerships we can achieve protection for the canyon and sustainable development for the tribe.

Currently, the tribe, through its Grand Canyon Resort Corporation, operates Hualapai River Runners and Grand Canyon West within the AOC. Helicopter operations associated with Grand Canyon West have significant impacts upon the natural quiet of the park and the Hualapai Reservation. Both the tribe and NPS have concerns about the impacts caused by the helicopter noise, visitor traffic, and safety. An early success as part of our MOU process was the development of operational protocols for emergency response, as well as for river and helicopter operations. These guidelines, developed by a team representing the tribe, Grand Canyon, and Lake Mead, represent a positive move toward improving health and safety conditions for visitors and employees of the area.

Other subcommittees are beginning to work on additional areas of mutual concern. Fees and permits, integrated resource management, carrying-capacity standards, zoning, and inventory and monitoring protocols are all part of our plan for the future. While we recognize that the difficulty is working through many of these issues, we know that not addressing them will lead to increased tension and the inability to move forward managing a resource important to all of us.

Without the foresight of tribal leaders and park managers, this process would have stagnated, leading to the never-ending spiral of conflict between the NPS and the tribe. Through this process, we hope to be able to come to resolution on issues of concern to all parties, confronting difficult situations and working through them to a resolution amenable to all.

Although we have been working on this for two years, we are just beginning. We have addressed some easy issues, and are now entering negotiation on more difficult issues such as hunting, commercial uses, carrying capacities, and upriver travel. Only through ongoing dialogue can we hope to develop the mutual respect and trust required for a true partnership. If we are successful, the strength of what we have begun may help foster other partnerships between federal agencies and Indian tribes.

43 Taking the pulse of collaborative management in Canada's national parks and national park reserves: voices from the field

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Introduction: voices from the field

The concept of collaborative management is increasingly gaining currency worldwide as a viable alternative for reducing conflicts and achieving more sustainable management of resources within national parks. It has been defined as "institutional arrangements whereby governments and Aboriginal (and sometimes other parties) enter into formal agreements specifying their respective rights, powers and obligations with reference to the management and allocation of resources in a particular area" (RCAP 1996). With over 25 years of experience with collaborative management, many are looking to Canada for lessons learned.

Over the years, a rich literature has emerged on the collaborative management of national parks in Canada. Topics range from parks policy and collaborative management under land claims (e.g., Fenge 1993), to particular case studies (e.g., Sneed 1997), to specific issues such as wildlife management and hunting (e.g., Morgan and Henry 1996; Morgan 1993) and economic opportunities for aboriginal people (e.g., Budke 1999). There have been attempts to provide a comprehensive overview of the many interrelated issues (e.g., Morrison 1993), and there are many allusions to parks issues in larger treatments of collaborative management (e.g., Notzke 1994; Berkes 1994, 96; Bonin 1995; Notzke 1995; RCAP 1996; Campbell 1996). However, there is no recent literature highlighting the voices and experiences of the hands-on experts in collaborative management in national parks: namely, the people working on the boards. How do they feel the process is working? What are some of the major issues they have had to contend with? What are some of the responses they have developed for dealing with these? How do they *do* collaborative management?

Purpose and methodology: taking the pulse

This paper synthesizes the findings of a project (Weitzner 2000) undertaken to fill this literature gap. Specifically, it "takes the pulse" of four experiences of collaborative management in Canada's national parks and national park reserves: Gwaii Haanas Haida Cultural Heritage Site and National Park Reserve (British Columbia), Kluane National Park (Yukon), Tuktut Nogait National Park (Northwest Territories) and Wapusk National Park (Manitoba). These were selected on the basis of their geographical locations and different sociopolitical contexts, and because they involve collaborative management subject to land claim agreements or other legally binding agreements. The paper highlights responses board members—and sometimes entire boards—have developed for dealing with several emerging issues.

The discussion is based on 21 interviews conducted with board members, park superintendents, and senior Parks Canada officials between November 1998 and December 1999. Most were conducted by telephone using an interview guide containing open-ended questions. The criteria for which board members to interview

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included speaking with at least one aboriginal member, one Parks Canada representative, one non-aboriginal member (where appropriate), and the park superintendent.

This type of research is particularly important given the policy shift towards collaborative management on behalf of Parks Canada. Spurred by the settlement of land claims, the entrenchment of aboriginal rights in the Canadian Constitution, and the increasing awareness of the importance of public participation in management decisions, there has been a proliferation of collaborative management arrangements in national parks. Currently, of Canada's 39 national parks and national park reserves, 11 are being collaboratively managed, with approximately six at earlier stages of negotiation and planning. Indications are that all future national parks and national park reserves will have some type of collaborative management board in place (D. Yurick, personal communication, 1999). "Taking the pulse" of this new form of management as it evolves is critical, as it provides a point of departure for reflection, learning, and re-thinking.

Discussion of emerging issues

Emerging issues fell into four broad, inter-related categories: fundamental issues, structural issues, process issues, and issues related to outcomes. What pervaded all interviews was the challenge inherent in negotiating and adapting to new relationships and processes that attempt to bridge two very different ways of seeing, knowing, and working.

Fundamental issues: balancing power

Sovereignty, nation-to-nation relations, authority, and control. The largest issues underpinning the collaborative management arrangements were associated with different perspectives on who owns and has jurisdiction over the land, how to balance authority and control between different parties, and who should have the final say in decision-making. The central tension relates to the balance of power and negotiation of relations between the Government of Canada and First Nations, particularly in light of increasing recognition of aboriginal rights to ancestral lands through the court system, and the settlement of far-reaching land claims that recognize a form of indigenous sovereignty. How can collaborative management reconcile the sovereignty and decision-making of indigenous peoples with the current framework of government in Canada? Several different responses to deal with the sovereignty issue emerge from the cases.

- *Response #1: Agree to disagree*. According to a senior Parks Canada official, the arrangement "that has gone the farthest" in terms of achieving "co-management" is Gwaii Haanas. The response here was to enshrine both positions on ownership and jurisdiction in the agreement: in other words, to agree to disagree. A Haida board member attributes the success in negotiating the agreement to the Haida having been in control of their territory when they were approached by Parks Canada to establish a national park: "We were already in charge, and we didn't really need them.... Canada joined us in management." The Haida did not acquiesce to Park's Canada's position that the Minister is ultimately responsible for decision-making, because they had never entered into a treaty with Canada or given up their land. However, even though the agreement recognizes both the Haida and federal positions on jurisdiction, Parks Canada maintains that the Minister has the final responsibility and ultimate decision-making power, and it will adopt this position in the event of a disagreement.
- *Response #2*: *Design a strong board and process*. Other negotiations started from the assumption that the Minister has final decision-making powers, and focused instead on designing as strong a board as possible, building into the agreement a

process allowing the board a second opportunity for responding to a Minister's rejection of a recommendation.

- *Response #3: Ensure equal representation of all parties, with a limited board role for the park superintendent.* In three out of the four cases (Tuktut Nogait, Kluane, and Wapusk), superintendents have no voting powers (although in Wapusk the superintendent votes on interim management guidelines and the management plan).

In the final analysis, however, many board members stressed that although a strong agreement is in place, what collaborative management means, and how it is operationalized, is largely a question of personality, individuals, and willingness to implement the concept in practice. And in the view of several people interviewed, the willingness to embrace boards as part of a new relationship where there is shared responsibility—rather than seeing them simply as "just advisory bodies"—depends to a large extent on the attitude of the park superintendent.

World-views, values, and conservation. Reconciling different world-views, values, and ideas about what conservation means and how it should be carried out, particularly in relation to national parks, was a recurrent theme in the interviews. The very notion of setting aside a piece of "wilderness" and prohibiting human activity is foreign to many aboriginal people's beliefs about the relationship of responsibility between humans and nature, and is increasingly questioned in Western conservation circles as the idea of sustainable use gains currency (e.g., Stevens 1997; Berkes 1999).

According to one board member whose view was echoed by several others: "A park is not a normal concept; we spend a lot of time discussing what a park is when we're negotiating." Another emphasized the cultural component of parks, noting that this is just as important to First Nations as ecological integrity, but is still quite foreign and inadequately addressed by Parks Canada: "Our intention was protecting the land as a means to protect our culture."

- *Response #1: Define "national park" and use interest-based negotiation*. One park negotiation process used interest-based negotiations to come to a shared understanding of what a national park comprises, and included this definition in the agreement, along with local resource use rights.

Structural issues: balancing representation

Who is represented on the board depends on each particular context. For most northern parks, this is not such an issue, because the primary affected parties tend to be the aboriginal peoples who live near or use the park, the territorial government, and the federal government. But in more southern parks (i.e., those that are located within provinces), such as Wapusk and Gwaii Haanas, and in areas where the First Nations represent a minority, such as at Kluane, more interest groups tend to be involved.

- *Response #1: Include both First Nations and other community representatives.* At Wapusk, there is representation not only from the Fox Lake and York Factory First Nations, the provincial and federal government, but also from the town of Churchill. In fact, there are two representatives per stakeholder group, making this one of the largest national park boards in Canada (10 members).
- *Response #2: Include those people who have ownership interests in the land, and, after building a relationship among board members, establish the authority of the board and settle claim issues, include other groups' interests in the process.* After nine years in operation, the Gwaii Haanas board (comprising two Haida and two government representatives) is developing an advisory group of stakeholders, such as representatives from each community and tourism operators. However,

the board will have the power to accept or reject their advice. According to one board member, it is only now, after nine years of developing a relationship, working together, establishing the authority of the board, and dealing with the "big issues," that board members can consider including other interest groups in the process.

Process issues: balancing procedural cultures and knowledge systems

Meetings: differing processes, cultures, and styles. Each board has developed a very different process for undertaking meetings, which is adapted—to a lesser or greater degree—to suit the particular context, cultures, comfort levels and styles of the people involved. For example, early on—and in response to conflicts that took place—board members at Gwaii Haanas rejected the idea of working using a formal structure with agendas and minutes, recognizing that it "simply wouldn't work." Instead, meetings are called on an as-needed basis, and there is flexibility with regard to how many people need to be present to hold a meeting, as long as there is one representative from each stakeholder group. The discussions at meetings tend to be open, without any one person facilitating. Issues to be discussed are presented on a two-page issue form sheet. After an open and frank discussion, a course of action is recommended. The action, timeline and responses are recorded on the issue sheet, and signed off by the Haida and Parks Canada co-chairpersons.

To a large extent, the question of how to appropriately integrate different ways of conducting meetings has to do with the number of times people meet face-to-face per year and how long members have worked with each other, as well as the chairperson's skills. In general, the process is more formal in those boards that meet face-to-face only four times a year (e.g., Wapusk) compared with boards that meet 30-40 times per year, and that have been in operation for a longer time (e.g., Gwaii Haanas).

Other issues that emerged regarding process include:

- *Consensus decision-making.* The one aboriginal contribution to board process adopted by all boards is consensus decision-making.
- *Language and technical jargon*. On all boards English is the working language. The difficulty is that English—and particularly Park's Canada's technical jargon—is often inadequate and unable to reflect First Nation peoples' reality and world, and the clash between the idea of managing the land and living on the land. This was pointed out by an aboriginal board member of Kluane: "If you get a First Nations person from the land and you give them a book on management planning, you have two different worlds.... This isn't my world. Kluane is my world."
- *Working relations, respect, and trust.* Many members agreed that respect and trust are critical elements of good working relations. All members said there was respect among the board members, with one (government) member qualifying his "yes" response by saying there is a healthy disrespect for government. One First Nations member noted "you've got to have [respect], or [collaborative management] wouldn't work."

Traditional knowledge

Incorporating traditional knowledge into decision-making was cited as critical, and all of the collaborative management agreements refer to recognizing and using traditional knowledge in planning. However, the only board that uses it extensively in both cultural and natural resources management decision-making is Gwaii Haanas. According to a Gwaii Haanas board member, "We've done lots of work on archaeology, Haida place names, ethnobotany, genealogy, etc.... A lot of our management plans and back-country plans come from traditional knowledge. When we do decision-making or planning, we always consider traditional knowledge. Sometimes with site plans, we bring in all the hereditary chiefs to discuss traditional knowledge." The Haida have indexed their songs, and these are used in decision-making.

Other boards do not use traditional knowledge as extensively for a variety of reasons, including:

- The perception that traditional knowledge is brought to the table through aboriginal board members, and that it is not necessary to consult beyond this.
- The lack of a solid traditional knowledge base in cases where people either (1) have been prohibited from using resources in the park for an extensive period of time, such as in Kluane; or (2) do not have a long history in the area, as in Tuktut Nogait, where the original users were the Thule and Copper Inuit.
- Lack of knowledge in how to appropriately collect and use traditional knowledge in decision-making.

With regard to wildlife management, however, traditional knowledge is used in decision-making, although most often at the regional rather than the park-board level.

Outcomes: balancing benefits and challenges

Participants agreed there is a mix of social, political, and economic benefits, with less stress on the economic, and more on the political, social, and environmental aspects. They highlighted that for people involved in collaborative management, the process is just as important—and inextricably connected with—the "products." The benefits and challenges related to the fundamental, structural, and procedural issues are discussed in Table 43.1.

Conclusion: crossing boundaries

This synthesis shows that collaborative management provides an important vehicle for crossing boundaries "on the ground, in the mind, and among disciplines." While there is no blueprint approach, some of the necessary conditions that emerge for crossing boundaries through collaborative management include:

- *…in our minds:* There must be: respect among the parties (for differences in values, world-views, cultures); basic trust; and an open and positive attitude towards embarking on new relationships, and seeing boards as a legitimate decision-making body.
- *…in knowledge systems:* Traditional knowledge must be incorporated into decision-making to the fullest extent possible.
- *…with regard to process:* Differing meeting cultures and decision-making processes need to be more balanced for meaningful participation to take place.
- *…on the ground*: There must be protection of aboriginal rights in national parks.
- *…with regard to outcomes:* There must be mutual benefits (social, political, or economical).

As one participant stated, in the final analysis "the challenges [in collaborative management] are all in people's heads."

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Benefits	*Challenges*
· Direct economic benefits, including: local staff being hired to work in the park; honoraria for participating on the collaborative management board; tourism (mentioned as an important factor only in the case of Gwaii Haanas); cost-sharing between government agencies with regard to research in the park (mentioned by a provincial member of the Wapusk board). · Having a voice in decision-making (pointed out by several aboriginal members and a representative of the Department of Natural Resources on the Wapusk board). · Increasing indigenous political and cultural self-empowerment, self-respect and stewardship, and protection of resource rights. · Better environmental decision-making and increased accountability and transparency. · More efficient operations; better communication and conflict management. · Better working relations; mutual learning and increased cultural understanding. · Increased job gratification and fulfillment, particularly for Parks Canada staff. · Increased profile for Parks Canada as a leader in a new type of management.	· Facing underlying issues and assumptions in adapting to and implementing a new relationship and way of working, including different perspectives on the role, authority and power of the board. This can lead to turf wars and prevent boards from having a long-term view. · Reconciling different ideas about the nature of national parks. · Trying to adapt to the local situation and build in flexibility, regardless of Parks Canada's rules. · Efficiency issues. The good use of time and money, and "finding the level of decision-making and issues where the board's involvement is warranted, so we have less issues to deal with." · Timing/deadlines and trying to bridge the gap between Parks Canada's guidelines and board processes. In cooperative management, decisions take a lot longer. There is also lots of paperwork and red tape related to the various jurisdictions involved. · Clarifying roles and responsibilities, and increasing communication. · Distance and communication. Having board members that are spread out, and trying to find the time to meet. · Zoning and resource-use issues, particularly for people not considered traditional users. · Ensuring equity and fairness in addressing the needs of all board members. · Park's Canada's inflexible hiring procedures, which make it difficult to hire aboriginal people without going through all the in-house procedures first. · Translating language; clarifying jargon and management planning concepts. · The acceptability of collaborative management to First Nations (mentioned in relation to the Gwaii Haanas). A Haida representative noted that some of the greatest difficulties were "amongst our own people—some don't see the value of having a cooperative thing, and think we should do it ourselves."

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44 Overview of subsistence in Alaska

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Introduction

The native presence in Alaska's national parks, and increasingly in the rest of the National Park System, comprises a broad spectrum of associations, uses, activities, and concerns. These include consumptive uses, as exemplified—but not limited to—legally provided subsistence in Alaska; innumerable ceremonial activities with attendant harvest of symbolic plant, animal, and mineral materials—both known and unknown to the National Park Service (NPS) and other agency officials; and ongoing concerns and actions relating to protection of shrines, burial grounds, and other sacred and historic sites.

The fact is, national parks and other designated preserves overlay—in their entireties—old homelands of traditional peoples. In fact, not a square foot of the entire country lacks site-specific or contextual associations with the multiple millennia of Native Americans' cultural histories. That is why, in a new era of cultural awareness and inclusion, these multitudes of tribes and nations seek our welcome and sensitive accommodation as they continue, or renew, traditional ties to their old homelands.

I have a particular interest in the Alaska subsistence issue. For I was fortunate to be involved with the gifted NPS crew that fashioned the philosophical concept of subsistence, helped develop the legislative language and operational frame for the subsistence title in the Alaska National Interest Lands Conservation Act of l980 (ANILCA), and implemented the subsistence program in the new NPS Alaska Region. Notable among these people were the leaders of the 1970s NPS Alaska task force, Ted Swem in Washington, D.C., and Al Henson in Alaska; members of the task force, including Bob Belous, Stell Newman, Ray Bane, Dick Nelson, and Zorro Bradley; and the first Alaska regional director, John Cook, under whose direction the delicate task of implementation was accomplished on the ground and in the villages.

The legal thread

What happened in Alaska in the period 1959-1980 was this: A great federal commons, the territory of Alaska—one-fifth of the nation's land base—was divvied up into multiple ownerships. It was a variation on the progression from open to fenced range in the trans-Mississippi West.

But further back in history had been the Russians, and much further back in history—at least 12,000 years back—came the First Americans. Over the millennia, in their many tribes and culture groups, these early people settled into the country and evolved as the country evolved. By the time the Russians came in the mid-1700s, the basic patterns of native settlement and culture had been established: Athabaskan Indians in the Interior; Eskimo peoples along the coasts and lower rivers of "mainland" Alaska; Aleuts on the Alaska Peninsula and spanning the Aleutian Chain; Tlingit and Haida Indians in Southeast Alaska.

The first Russians were rough, plundering fur traders. In time, Orthodox Russian missionaries would reform the Russians and convert the natives. Given more time, and much intermarriage, Russian America mellowed into an isolated, rather easy-going colony. With the near-extinction of sea otters, whose pelts had been the colony's economic mainstay, Russian America became, in effect, a missionary colony of no great value to Mother Russia. So Alaska was sold to the United States in 1867.

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The treaty of purchase stipulated that the native peoples would be allowed to continue their traditional ways of life, i.e., they could live off the land as they always had.

With the statehood proclamation of 1959, the state of Alaska began selecting its land bequest from the federal domain—which constituted 99% of the former territory. Alaska's land grant totaled 104 million acres—larger than all of California. State land selections impinged in native traditional-use areas, which mobilized Native Alaskans to seek their own land claims, resulting in ANCSA, the Alaska Native Claims Settlement Act of 1971. It was understood that the 44-million-acre native land settlement did not comprehend the extensive traditional-use areas, but rather constituted a core settlement and economic land base. Thus came, in ANILCA, the subsistence title, which did recognize and provide for ongoing traditional uses in most of the national interest lands designated in the act. ANILCA further declared that the cultural values of these traditional uses are of national significance as part of the nation's cultural heritage.

That, in brief, is the legal trail: from ancient possession and occupation, to treaty obligation, to the recent three interacting and structuring laws—statehood, native claims, ANILCA.

The moral imperative

There was some flesh on these legal bones as well. In part, ANILCA's subsistence title responds to the modern plight of indigenous peoples all over the world. Anthropologists, such as Colin Turnbull in Africa, and environmental conservationists, such as Raymond Dasmann in the USA, had mobilized concern around the world to halt the remorseless destruction of indigenous cultures. They said that the careless invasions and extractive havoc imposed by the industrialized nations on remote cultural homelands and habitats—as well as the outright removal of indigenous peoples attendant on establishment of national parks and wildlife preserves—constituted genocide.

Not only was this morally repugnant, it also meant immense loss of traditional knowledge to the world at large: knowledge of plants, animals, and the innumerable intricate relationships between humankind and nature that living-off-the-land peoples have accumulated over the millennia. Modern people, insulated from the real world by encapsulating built environments, have lost these bodies of knowledge and relationships, which all of us, in our ancestral cultures, shared not so long ago.

So, said people such as Turnbull and Dasmann, and organizations such as IUCN, and doctors seeking plant medicines in a world overwhelmed by rapidly mutating bacteria and viruses, the loss of a culture should be equated with the extinction of a biological species. Each culture that disappears takes with it to oblivion mental and material toolkits acquired over thousands of years of specific-place adaptation—each history as unique as a genome, and never to be replicated.

Each of these losses, then, can be equated with the sacking and burning of a culture-specific Alexandrian library. And each such loss is a combined moral and pragmatic disaster for the world at large, and forever down the generations.

This is why the ANILCA subsistence title is important. For the daily activities, methods, and decisions that subsistence encompasses are the milieu, the defining properties, of the culture in question. To put it another way, the demands of living off the land—that particular combination of ecosystems that makes up the homeland—define the culture. Without access to traditional landscapes, traditional activities cannot occur and traditional cultures die.

ANILCA is as much sociocultural law as it is conventional conservation and preservation law.

But of course NPS, and other ANILCA-mandated agencies, are not keepers of cultures. We have enough problems running efficient motor pools. We are, in cooperation with the people whose homelands the parklands overlay, the keepers of cultural landscapes. These cultural habitats, in terms of our function, are landscapes of cultural choice. The strength of local tradition will, in the long run, determine the choice. All we can officially and competently do is preserve the natural and cultural habitats. The option, and the fullness, of cultural perpetuation—consistent with the legally prescribed purposes of the parklands—is up to the homeland people themselves.

The how of subsistence

Subsistence, as an operating program, is based on broad premises and principles derived from ANILCA, and must be in consonance with the statutory purposes of parks and other conservation units.

Experience has shown us that tight regulatory modes—the finished regulatory package, boxed and beribboned—do not work. Subsistence comprises multiple, shifting factors—social, biological, and geophysical. Examples: (1) A sequence of severe winters brings on a caribou-herd crash. (2) Commercial-fishing interdictions on the high seas (or, as recently, on the lower river) wipe out Yukon River salmon runs.

In old times, Caribou Eskimos would hunt more sheep in the Brooks Range, or they would migrate to the coast so they could hunt seals until the caribou came back.

Deprived of the annual bounty of salmon biomass from the ocean, Upper Yukon Athabaskans would make similar adjustments—compensating by hunting more sheep, more moose, and more small game, plus more fishing for white fish, pike, etc. Or if—as is often the case in that hungry country—these secondary and tertiary food sources were scarce also, the people would have to quickly migrate to avoid starvation.

These days, given permanent villages with schools and medical centers, migration is possible only for a select few. Thus, the compensatory shift to secondary and tertiary food sources can be more urgent. Such resource shifts inevitably require new and expanded hunting zones. These sorts of considerations tend to compound, day by day. It's sort of like a kaleidoscope: each turn of the lens produces a new design.

Subsistence management, then, requires ongoing adjustments to square with the shifting specifics of subsistence resources, within the general parameters and purposes of the parkland. This is why hard-set regulations and inflexible lines on maps are anathema to subsisters.

What we need to further develop and perfect is the ongoing negotiation process, a constant, rolling negotiation regime. Essential to make that regime work are knowledgeable park superintendents with much-devolved power of decision. And to make informed decisions, the superintendents must be advised by the best possible staffs: both subsistence program managers and onsite subsistence coordinators, the latter spending much time in the villages and camps to keep abreast of changing circumstances, as well as nurturing the trust relationship with the local people that keeps communications going. The importance of continuity of personnel in these operating positions cannot be overstated. That's why local people should get priority for these positions. In practical terms, wherever possible, it should be mandatory that the onsite coordinators be local people. Otherwise the whole delicate house of cards can tumble in a heap when the new face hops off the plane. (For my money, a good model for this personnel setup is in place at Lake Clark, with Mary McBurney and Karen Stickman carrying the flame. I'm sure others exist, but I had the chance to see these folks in action at the GWS Conference.)

From the subsisters' end, the Regional Subsistence Resource Councils, made up of local people, act as information clearinghouses and self-regulators, and as the negotiators on the other side of the table. Their interest is to assure that park management and subsistence uses are in perpetual, sustainable balance.

The joint monitoring by park management and the resource councils aims at a dynamic balance involving both resources and the negotiation process. The goal is the sort of enlightened self-interest shared by managers and councils alike that brings them together. For both need healthy habitats—healthy parks, healthy homelands. These two designations may be distinctive in purpose, but they share the same reality, the common ground itself.

This commonality, with distinctions of purpose, is more than nice. It is necessary in the political and resource-economics climate of Alaska. If we hang together, we can prevent the predation of Alaska's brand of resource politics. Otherwise, we could well hang separately as Alaska's oil boom falls further toward bust.

45 Managing subsistence activities in the national parks: general prohibitions vs. local sensitivities

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In Alaska, managing subsistence activities is one of the most challenging tasks of federal land management agencies. Contentious and widely misunderstood, subsistence conjures up a host of meanings; how the term is defined is largely in the eyes of the beholder. Non-natives, for example, typically view the issue in narrow economic or biological terms, while to natives, subsistence encompasses an entire world-view with a host of cultural and lifestyle connotations. Because subsistence has so many emotional ramifications, federal lawmakers have tried as best as they can to simply avoid using it. As a result, subsistence is to Alaskans as pornography was to Supreme Court Justice Potter Stewart when he said, "I shall not attempt to further define [it], but I know it when I see it" *(Jacobellis v. Ohio*, 184, 198).

In the fall of 1980, the National Park Service (NPS) became a major player in the world of subsistence management. That November, Congress passed the Alaska National Interest Lands Conservation Act (ANILCA), and a few weeks later, a swipe of President Jimmy Carter's pen made NPS the custodian of more than 43 million acres of new parks, monuments, and preserves—about 12% of the state. More than 90% of those new parklands was open to subsistence uses: hunting, fishing, gathering, plant collecting, and so forth (Williss 1985, 238-239) Those who were eligible for subsistence uses were both native and non-native; the state of Alaska had fought long and hard to avoid racial criteria in setting a subsistence preference, and NPS officials were perfectly willing to go along with the state because of difficulties the agency had had outside of Alaska setting racial criteria for subsistence activities *(Congressional Record* 1980, 10545-10546) The key qualification in Alaska was that subsistence users be local rural residents. Once ANILCA became law, NPS officials had to think long and hard before formulating rules pertaining to subsistence, because the agency had simply never previously faced the challenge of managing hunting and fishing activities on millions of acres of designated parkland (Williss 1985, 284). While NPS had never attempted to manage subsistence on such a huge magnitude before, it did have a long-established track record of dealing with subsistence issues, and a chronology of agency decision-making shows some consistent, predictable patterns.

Subsistence issues, in fact, have been debated in the parks since long before NPS was ever established; and indeed, Congress wrestled with subsistence in its debate over the bill that established Yellowstone, the nation's first national park. In 1870, two years before the park became a reality, the Washburn exploring party encountered various abandoned Shoshone camps and used a number of well-established Indian trails. But perhaps because of the party's zeal in promoting the idea of a park, it reported to Congress that the Yellowstone country was a primeval wilderness that was "never trodden by human footsteps" (Spence 1999, 42-43). Keeping in mind that the Washburn expedition came more than ten years before the Northern Pacific built its railroad through the area, and also keeping in mind that the Montana–Wyoming border country was arguably a fairly dangerous place—the Battle of Little Big Horn would not take place for another six years—advocates for protection of the Yellowstone country may well have felt skittish about Native Americans. So Congress responded to that skittishness by including language in the park's enabling act stating that the secretary of the interior "shall provide against wanton destruction

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of fish and game found within said park [and] shall also cause all persons trespassing upon the same after the passage of this act to be removed therefrom..." (Dilsaver 1994, 28-29). A few years later, the Shoshones were relocated to a nearby reservation, and in concert with that action, Yellowstone superintendent Philetus Norris ordered them to stay away. He gave three reasons for his action. First, he said that "Yellowstone is not Indian country, and no natives lived in the park"; second, "Indian fear of geysers kept them out of the park"; and finally, "Yellowstone is for the use and enjoyment of all Americans." That attitude, moreover, held sway for many years; in 1894, Congress passed a law prohibiting hunting "of any bird or wild animal" in the park, and it also allowed fishing only by means of hook and line (Spence 1999, 55-58; Keller and Turek 1998, 23-24; Dilsaver 1994, 36).

At the other early national parks, attitudes toward Indians and subsistence were only slightly more conciliatory. At Yosemite, for example, the establishment of a national park in 1890 was immediately followed by the arrival of the U.S. Army, which did its best to limit Indian hunting activities. Park administrators, however, were more tolerant. For years afterward, Indians lived and hunted in Yosemite Valley, and a small "Indian village" was located there (Spence 1999, 106-115; Keller and Turek 1998, 20-22). At Mount Rainier, a band of Cayuse Indians hunted in the Sunrise area until 1916, when park rangers fined them for their actions. But natives, paradoxically, were encouraged to continue with their spear fishing and berry picking (Catton 1996, 14-20; Keller and Turek 1998, 25-26). The attitude seemed to be that Native Americans were tolerated in the parks, but only so long as they remained a minor part of the landscape, and only so long as they did not pose a real or perceived threat to either the park visitor or park resources.

The establishment in 1916 of NPS gave officials an excellent opportunity to provide some consistency in managing the thirty-six parks and monuments that composed the National Park System at that time. Stephen Mather and Horace Albright, the agency's founding fathers, had a genuine interest in archeology and native artifacts; they also had a genuine concern for Indians and recognized that tribes had a historic, inherent relationship with parks. But they also thought, rightly or wrongly, that park visitors preferred romantic stereotypes and "picturesque" misconceptions of Indians rather than the realities of Indian life. This attitude is perhaps most starkly drawn in Horace Albright's book, *Oh Ranger!*, where he states that the western national parks were attractive because they gave the visitor the opportunity to find "real, live Indians! ... the kind that wear feathers, don war paint, [and] make their clothes and moccasins of skins.... The best place for the Dude to see the Indian in his natural state is in some of the national parks" (Keller and Turek 1998, 28, 232). As to the legitimacy of subsistence activities, the government's attitude was clearly stated in Interior Secretary Franklin Lane's well-known 1918 letter to Director Mather. In that letter, Lane wrote that "hunting will not be permitted in any national park," and he further defined fishing as a "favorite sport," not as a consumptive activity. The die was cast: the parks would be off-limits to subsistence hunting and fishing (Dilsaver 1994, 62-65).

Despite the rigidity of that rule, subsistence harvesting took place in many of our nation's parks during the years that followed the 1916 act. In some cases, the sheer lack of staff forced NPS officials to recognize that the creation of a park could not stop centuries-old hunting patterns, and in other cases, park officials approved of small-scale harvesting so long as more significant park values were not jeopardized. At Mount McKinley, for instance, subsistence was legal for more than ten years because the mining town of Kantishna was on the park's northern border, and Alaska delegate James Wickersham refused to support the park unless Kantishna miners were allowed a hunting privilege (Brown 1991, 93). At other parks, arrangements were more informal. At Glacier, for example, the eastern park boundary encroached upon traditional Blackfeet hunting territory, and for more than thirty years relationships with NPS were strained as occasional arrests were made followed by sporadic NPS attempts to purchase Blackfeet land (Spence 1999, 177-196; Keller and Turek 1998, 43-61). At the Grand Canyon, the establishment of the park in 1919 included Indian Gardens, where several Havasupais had long lived; they remained there until 1928, when park officials evicted them (Keller and Turek 1998, 131-139). At Mesa Verde, most of the park had long been part of the Ute Mountain Indian Reservation, and the Utes were angry at park officials because they had been dispossessed of thousands of acres of land in the congressional act that had established the park. NPS officials were well aware of that anger, and in hopes of defusing the tension they chose not to prosecute natives who hunted, grazed livestock, or cut timber on NPS lands (Keller and Turek 1998, 31-41). The Park Service, during this period, rarely practiced overt discrimination toward local Indian tribes; both at Mesa Verde and elsewhere, they simply treated Indians as an invisible part of the landscape and failed to pay attention to them. In this respect, NPS was no different from other federal land management agencies.

During the 1930s, the federal government's attitude toward Native Americans began to change. The Franklin Roosevelt administration declared an "Indian New Deal," and the ramifications of that declaration produced a more even playing field between natives and the various land management bureaus (Spence 1999, 134). In Washington state, for example, a long-running struggle over how best to protect Roosevelt elk populations was resolved when Olympic National Park was established in 1938. The Olympic Peninsula, then as now, was home to a variety of native groups, and perhaps at the insistence of Interior Secretary Harold Ickes, the park bill contained language explicitly protecting Indian treaty rights. Here, as elsewhere, most local Indians went unnoticed to Park Service authorities, and as a rule, park rangers did not over-react when they heard about occasional Indian elk or deer hunts on park land (Keller and Turek 1998, 91, 107-08, 122-23, 127-28)

Another major park battle that took place during the FDR years focused on the Everglades country in southern Florida. This "river of grass" had long been home to the Seminole Indians, but the huge land boom of the 1920s resulted in urban growth and dwindling wildlife populations. When NPS officials first broached the idea of an Everglades park in 1930, they discovered that the federal government had the legal right to remove Indians from the proposed park area. But neither they nor anyone else relished the idea of forcing Indians from their land, so a key sentence was added to the 1934 act authorizing the park; it said that "[nothing] in this Act shall be construed to lessen any existing rights of the Seminole Indians which are not in conflict with the purposes [of] Everglades National Park." During the decades that followed, various federal officials aired occasional proposals to either remove the Seminoles from the park or to restrict the extent of their harvesting activities. But those proposals were never implemented, and natives continue to hunt, fish, and trap within park boundaries (Keller and Turek 1998, 219-31).

Prior to the 1950s, there were several places in the National Park System where subsistence was a legal, open activity (Sellars 1997, 259-60). Hunting and sheep grazing, for example, have always been condoned at both Navajo and Canyon de Chelly national monuments—primarily because both units are on Navajo tribal land (Keller and Turek 1998, 193-94, 206-207, 211). And at Glacier Bay National Monument (as it was then called), seal hunting was legalized because the Bureau of Indian Affairs, in support of natives in the nearby village of Hoonah, worked out a series of cooperative agreements on their behalf (Catton 1995, 103-132). Subsistence fishing, moreover, was allowed at several sites, most of which were located in territorial jurisdictions. At Hawaii National Park, the Kalapana extension of 1938 expressly allowed Native Hawaiians the right to fish above the high-tide line, and subsistence fishing was also allowed in Virgin Islands National Park (Somers 1998; Collier 1998). And at places such as Fort Pulaski National Monument in Georgia, NPS officials have long allowed so-called "protein fishing" by indigent local residents, even though the practice is officially illegal (Hatten 1998).

Many long-established park units, moreover, have long permitted the collection of plant materials for either food, craft, or ceremonial purposes. Legislative language pertaining to both Organ Pipe Cactus and Saguaro national monuments explicitly allowed the Tohono O'odham to gather cactus fruit, and in at least ten other NPS units, authorities informally allowed local residents to collect such items as berries, pinyon nuts, and prairie turnip (Williss 1998; Wellman 1998; Bunch 1998). So by the early 1960s, NPS was still fairly ironclad in its prohibition against hunting. But its rule against subsistence fishing was less rigidly applied in the territories, and the agency seemed agreeable to many forms of subsistence gathering.

Beginning in the early 1960s, NPS began to become increasingly sensitive toward Native American values. In 1963, Southwest Region Archeologist Leland Abel headed the new Indian Assistance Program, a cooperative effort out of the Santa Fe office that provided cultural resource management and other services to Indian tribes throughout the region. (Birkedal 1999). Two years later, Congress broke new ground when it established two parks—Nez Perce National Historical Park and Hubbell Trading Post National Historic Site—that emphasized Native American values (NPS 1997). In 1968, the Southwest Region established a special Navajo Lands Group, headed by Art White. And in 1970, Congress established Apostle Islands National Seashore, which expressly protected rights for the Ojibwa to continue hunting, trapping, fishing, and rice harvesting (Keller and Turek 1998, 6-14, 234). Throughout this period, clauses in bills that created new park units allowed the local native population to continue with their traditional activities; and in the case of Badlands National Park, legislation establishing its South Unit allowed the Oglala Sioux to hunt in addition to other subsistence activities (Spence 1999, 135; Mills 1999). A final major action pertaining to harvesting activities allowed by park neighbors was when Congress, in October 1974, passed bills creating the first two national preserves: Big Thicket, in Texas, and Big Cypress, in Florida. Both of these units were created with the express purpose of allowing local residents to hunt so long as that activity did not interfere with the park's core values (Williss 1985, 166-168). And, to a large extent, it was the agency's mind-set during the 1960s and 1970s that guided Park Service officials as they worked out the subsistence provisions of ANILCA.

Based on this brief chronology, a few generalizations stand out. First, many of the Park Service's actions toward Native Americans during the agency's early years seem terribly outdated if not outright racist to us today. These attitudes, however, were not considered unenlightened at the time, and in some cases NPS managers were fairly progressive in their relations with local native groups. Second, it appears that the parks have become gradually more tolerant of activities practiced by park neighbors, because they have learned to recognize—in both rural and urban settings—the value of having good neighbors in furthering park goals. This tolerance, however, is usually expressed when a park is either established or expanded; and the corollary to that rule is that long-established parks are less likely to allow new subsistence activities than new park units. Finally, an overview of NPS actions during the 1960s and 1970s suggests that by the time ANILCA was passed, the inclusion of a subsistence provision and the creation of a series of national preserves was a logical bureaucratic move and not a dramatic break from what the agency had been doing all along.

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46 Living cultures, subsistence, and the inhabited wilderness

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The theme of this panel's session is about crossing boundaries to implement the vision. I would suggest to you that the greatest challenges and greatest potential for achievements for the National Park Service (NPS) over the next millennium will be to *cross cultural boundaries* and implement *true partnerships* for accomplishing that vision.

Some people say that marrying subsistence and cultural use to the national park idea is one of the most outstanding features in the story of Alaska's national parks. Others have serious doubts whether NPS has the willingness, courage, attitude, policy, or regulatory ability to truly work with living cultures and subsistence. The final chapter has not yet been written.

Inhabited wilderness

The focus of my presentation is about living cultures, subsistence, and the inhabited wilderness. But first, let's step back a bit in cultural time, say about 25 millennia ago. In Alaska, areas that are now called parks and wilderness areas encompass some of the oldest inhabited land in North America. Archeologists theorize that early humans entered the North American continent between 25,000 and 28,000 years ago, crossing over the now submerged land mass called the Bering Land Bridge. More contemporarily, radiocarbon-dated archeological sites put early humans on the Alaskan landscape 12,000 to 14,000 years ago, and more specifically within the Denali National Park area, 10,000 years ago. Most important of all, though, is that Alaska native people have maintained an intricate and vital connection to the land for countless generations—and that this vital connection continues to be essential for their cultural, spiritual, and economic way of life.

Natural ecosystems

Regardless of where one goes in Alaska, the fundamental truth is that Alaska native cultures have evolved with the ecosystems and landscapes since time immemorial. This relationship and connection to the land, water, and resources has remained unbroken. Congress, through the Alaska National Interest Lands Conservation Act (ANILCA) recognized the importance and significance of the cultural and subsistence component in Alaska's natural ecosystems, and incorporated protections into the law to ensure the opportunity to engage in a subsistence way of life.

Traditional ecological knowledge is the system of knowledge gained by experience, observation, and analysis of natural events that is transmitted among members of a community. In the subsistence economy, traditional ecological knowledge is used to find, harvest, process, store, and sustain natural resources that are needed for food, clothing, and shelter. It also includes the ability to recognize, avoid, and get out of dangerous situations. Traditional ecological knowledge is built on recognizing patterns in the environment in order to understand migrations and cyclic events that can be relied upon for food and safety.

Conservation and perpetuation of subsistence resources is part of the subsistence way of life that is mandated by traditional law and custom. Traditional laws, which

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are passed down from generation to generation, remain intact through repetition of legend and observance of ceremonies that where largely concerned with use of the land and water, and the resources therein.

Common to all Alaska native cultures are a number of guiding principles established and enforced through customary laws. Alaska native peoples are taught at a very young age that they are not to waste subsistence resources, especially fish and wildlife, and that they are to take only what is needed and when it is needed. They are to treat all living things with respect, and they are not to damage the land without cause. And most significantly, they are taught the importance of family and community and the need to share their harvests and resources with those in the community or village who are in need.

Customs and traditions

Geographically, Alaska is a huge and diverse state, and native cultures have evolved accordingly. What is customary and traditional for the Inupiat of the Arctic tundra north slope may be significantly different from the Athabaskan Indians of the interior boreal forest. What is customary and traditional for the western coastal Yupik Eskimos may be significantly different from the southeastern Tlingit and Haida, or the interior or Arctic-slope brethren.

NPS management and regulations need to be responsive to these regional differences in customs and traditional practices. In the past, NPS management has been a one-shoe-fits-all type of approach. Ecosystems and native cultures are not static in time. Environmental changes, resource availability, technological advances, and use practices have all changed over time and will continue to evolve. NPS policies and management need to be responsive in recognizing and accommodating culturally accepted and emerging traditional practices, where appropriate. The one-shoe-fits-all and stagnant regulatory process continues to pit NPS management against the dynamics of a living culture.

Alaska native cultures have seen great changes in this last century, including the imposition of Western laws and governments, radical changes in the economy and resource development, significant technological advances, global environment change, in some cases devastating losses in their populations to Western diseases, and, in recent years, improving health care. These changes have at times been beneficial, and at times traumatically impacting. Yet native people have adapted; they have had to be dynamic and flexible to survive. But there's one thing that has not changed, a basic link that has never been broken or abandoned: the fundamental connection between the native people and the landscape. For most Alaska natives, subsistence is synonymous with culture, identity, and self-determination.

Indigenous and Euro-American systems

Alaska native political systems operate to regulate subsistence practices in rural areas, particularly where Alaska natives comprise the cultural majority. Local power and authority tends to be decentralized across a number of subgroups, including kinship groups, clans, bands, villages, and tribal groups, depending upon the indigenous society. The recognized leaders with authority over local subsistence matters are usually elders, heads of kinship groups, and highly productive harvesters and processors.

Decisions are made by consensus for the local society and carried out collectively. These decisions follow and form the customary rules of the local society and occur within the context of existing state and federal laws. The decisions are political in content, not just economic, for they deal with issues of power, authority, land use rights, and proper use of village areas. The corpus of customary law dealing with subsistence is almost never codified in writing. It is usually transmitted through oral tradition, customary practice, or ritual. Group order and compliance in the native system is maintained primarily through social pressure and the weight of traditional sanctions within the local society. The indigenous system stands in stark contrast to the Euro-American resource management system.

The Euro-American political system operates through a centralized hierarchical political process involving state and federal branches. Each of these governments exerts control over portions of Alaska's lands, waters, and resources. Each government agency has a bureaucratic structure that regulates through statutory mandates, which often differ between the agencies. These agencies' centers of operations are located distantly in large urban areas such as Anchorage, Juneau, and Washington, D.C. Management of uses includes a complex system of licenses, permits, tags, allowable seasons, and bag limits that are established through regulations. These regulations are very often burdensome and culturally inappropriate in remote rural areas. Violators of fishing and hunting regulations are prosecuted in the judicial system and are subject to fines and jail sentences.

Cultural regulatory conflicts

Early interactions between the U.S. government and Alaska's natives were generally deplorable and, seen from a contemporary perspective, regrettable. Until the late 1970s, there were no laws that required the federal and state governments to pass fishing and hunting regulations favorable to native subsistence users. Without this legal requirement, fishing and hunting regulations in Alaska were created primarily to serve Euro-American commercial fishing interests, sport fishing interests, and sport hunting interests, and only secondarily subsistence interests. This type of fish and game management system created numerous problems for subsistence users. Many traditional fisheries and hunts were closed to subsistence users. Short sport hunting seasons were instituted in place of longer traditional hunting and fishing periods, such as winter hunts and spring waterfowl hunting and gathering. Furthermore, imposition of individual non-transferable fish and wildlife licenses, registration permits, drawing permits, and harvest limits were instituted in state and federal laws. The net result has been a forced departure from many traditional practices and a criminalization of many aspects of the subsistence cultural way of life.

A fundamental aspect of subsistence harvest is based upon efficiency and economy of effort. In most native cultures, there are households who are very skilled and successful as harvesters, whether it is fishing, hunting, or gathering. Typically in rural Alaska, these very productive households harvest for a large number of people or families in the village. Generally, 30% of the households in a given rural community typically account for 70% of the community's subsistence harvest. State and federal laws have only recently begun to change after years of litigation. In some rural villages in Alaska, court-ordered community harvest quotas with traditional harvest seasons have finally been re-established.

Cultural conservation conflicts

Sometimes even the best-intended conservation practices are in direct conflict with traditional Native conservation perspectives and beliefs. A good example of this is the Western practice of catch-and-release fishing recommended by agencies and sport fishing organizations. Native people are taught to respect all resources and that one never wastes, misuses, plays with, or disrupts subsistence resources, especially fish and wildlife. Their ethics teaches them that when fish and animals are mistreated, the natural order becomes disrupted and people risk future food shortages.

To play with fish by catch-and-release sport fishing is disrespectful and violates traditional values. It is believed that disrupting fish in this manner cause the fish to move away and perhaps never return. Native cultures are also very upset by the injury and mortality caused by sport fishermen playing with the fish. Studies have shown, and native people have witnessed, high rates of mortality as a result of poor catch-and-release techniques and handling practices. Improperly sized fishing tackle, barbed hooks, playing fish to exhaustion, mishandling of caught fish, improper hook removal, and poor release practices produce high rates of injury and mortality in fish. This is especially problematic for resident fish populations such as sheefish, rainbow trout, and pike, which can live to be 8-14 years of age. We do not have the time to discuss the full range of cross-cultural conflicts, but as you can see, there are huge cultural boundaries yet to be traversed.

Consultation and coordination

Through ANILCA, Congress mandated that agencies consult and coordinate with subsistence advisory groups regarding subsistence management issues. In NPS, we work most directly with our park subsistence resource commissions. We also work with local fish and game advisory committees, local tribal councils and regional native associations, the federal subsistence regional advisory councils for our area, and the federal subsistence board. These are all examples of Euro-American political systems of "*cooperative management*" where the advisory groups recommend and advise, but have no real say or direct involvement in the final decision-making process.

Federal and state subsistence statutes, crafted as compromises between federal, state, and Alaska native governments in the late 1970s and the 1980s, have not achieved adequate protections for native subsistence systems. Park Service regulations established in 1981 took a very conservative and restrictive approach in dealing with eligibility, access, and subsistence use. Understandably so: NPS had little experience in dealing with living cultures and consumptive uses to the degree provided for by ANILCA. Regulations were written as strictly as ANILCA and the public would allow, with the intention to limit subsistence use and activities to those levels, and places, and uses employed at the time of ANILCA's passage. Regulations and policies were written and imposed on a statewide basis for agency consistency and convenience. These types of management practices proved very awkward and dysfunctional for working with dynamic living cultures. It has taken two decades and numerous lawsuits to advance subsistence management to where it is today.

Cooperative management vs. co-management

For Alaska in the long term, resolution of difficult interactions between the indigenous and the Euro-American management systems should be achieved through additional changes in federal and state laws. In Alaska and all across the high Arctic, indigenous people are calling for recognition of the value of traditional ecological knowledge in regard to conservation, resource management, and development of regulations. In the best of circumstances, experts from Euro-American and indigenous traditions share and apply their knowledge cooperatively to solve management problems.

There are a number of good co-management models NPS should be seriously considering if they truly want to *cross cultural boundaries* and establish *true partnerships.* Good examples of these would be the Alaska Eskimo Whaling Commission's approach regarding the number of strikes and the harvest of bowhead whales, the U.S. Fish and Wildlife Service work with tribes and villages on spring migratory waterfowl hunting in the Yukon and Kuskokwim deltas, the state of Alaska's work with natives regarding harvests of walrus from the Round Island Preserve in Bristol Bay, the work of the Kilbuck caribou working group in the lower Kuskokwim drainage, or that of the regional advisory councils in allocating wildlife harvest quotas to villages through federal regulations.

These are examples of circumstances where Alaska native groups have organized resource management entities to represent their interests in the Euro-American resource management system. These entities are recognized and function as *true partners* with active involvement in the decision-making process. Under these agreements, common goals are identified, management approaches are developed in a negotiated process, and resource management plans are presented to native and non-native governing authorities for review and endorsement.

Conclusion

Having witnessed firsthand the transition from the territorial days to statehood, and the last two decades of federal subsistence management since passage of ANILCA, I am led to the conclusion that if the National Park Service is to be successful 50, 100, or 200 years from now in implementing the vision, it will have to cross cultural boundaries and establish true partnerships in some form of co-management. The challenges and measures of success for NPS in the 21st century go far beyond simple conservation and preservation by implementation of regulations and laws from afar. Ultimately, success will have to be found through true partnerships with local subsistence users, native groups, and park managers. To achieve the vision for the future, we must find a way to empower Alaska's living cultures and provide them a meaningful role and involvement with management decisions that could affect their lives, activities, and cultural practices. Only recently have these partnerships begun to be formed.

47 On common ground: an enduring wilderness as cultural landscape and biotic reserve

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Of all the American public lands set aside as an endowment for future generations, surely wilderness is the most fragile, misunderstood, and politically divisive of all. That should not be a surprise to anyone, for wilderness preservation is the result of a uniquely American form of social schizophrenia.

Our free-market economic system abhors a utility vacuum, while our form of government, in response to strong societal pressures, is compelled to find some counterbalance through legislation for the rapidly accelerating destruction of our natural and cultural heritage. However, the underlying reasons for conserving something of wild America are never simple or unified when one gets beyond the lawful purpose statements. To further complicate matters, the term "wilderness" has become so misconstrued and diluted in meaning as to be nearly all things to all people. The average American often talks as though anyplace out of town and beyond the edge of agriculture is wilderness.

If the goal of "civilizing activities" and the free-market system is to make maximum use of the natural world to improve the human condition, then preserving wilderness areas through legislation is an odd byproduct, like a alcoholic drinking up the kids' future and assuaging his guilt by buying them presents occasionally. Obviously, the unheralded standard of living we have achieved allows us the luxury to conduct this democratic experiment. Recent polls indicate that 75% or more of urban Americans, willing to talk to pollsters during supper, "strongly support the preservation of wilderness." I do not doubt for a moment that this broad mandate is like the Mississippi River: a mile wide and an inch deep. Scratch the surface of that support and confusion prevails. Wilderness is a 105-million-acre social anachronism. As a result of this growing confusion and rampant political correctness, these symbolic places have increasingly become targets for "deconstruction" from every quarter of society—even self-proclaimed conservationists of every stripe.

Before we focus on Gates of the Arctic National Park and Preserve as a cultural landscape, a couple of macro-scale wilderness preservation issues should be mentioned. On a global scale, our resource consumption and multinational corporate partnering in rampant extraction continues to seriously diminish the remaining wildlands of many other countries and destabilize their cultural traditions and subsistence economies. In this context, our high-minded calls for conservation are hypocritical in the extreme. On the national scale the political drumbeat of reducing threats to our national security by developing America's resources, thus reducing the length of the pipelines (but not the diameter), while conservation measures are pooh-poohed as an economic slowdown, are reverberating from coast to coast. These socioeconomic imperatives will seriously challenge the collective backbone and the fundamental principles of those who support preserving an enduring wilderness resource.

Of the many lesser threats that continue to seriously erode wilderness values, it is these that concern me the most. Our lack of interagency will to manage for a *spectrum* of wilderness areas, using as a yardstick measurable quotients of wildness and naturalness. In the National Park System, the wilderness areas at Fire Island National Seashore and Gates of the Arctic are as night and day. It is incredible that we would

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pretend otherwise. A "prudent person" would say that most designated wilderness areas, to one degree or another, require restorative actions to meet threshold standards we are loath to describe. We have long talked of rejuvenating our public education efforts to try to counter the loss of empathy for wilderness values in the rapidly changing face of America. Good luck counteracting the 24/7 corporate spin bombarding a public nearly devoid of any direct experiences with real wildlands. Further, our agency record in fulfilling stewardship responsibilities for wilderness in parks by successfully developing wilderness and backcountry management plans is abysmal. Lastly, there is the embarrassing fact that after seven years of teeth-gnashing over setting measurable performance goals mandated by the Government Performance and Results Act of 1993, the National Park Service (NPS) has no Servicewide wilderness stewardship goals at all!

No real surprises in this for most knowledgeable observers. The irony is that despite the well-documented reluctance of NPS to embrace the Wilderness Act of 1964 (Sellars 1998), the American people have repeatedly joined the wilderness concept to that of parks. Nearly 41% of the entire wilderness system in the USA is within parks, and more that 57% of the vast designated Alaska wilderness acreage is found in parks. With 52% of the entire NPS acreage designated as wilderness, and a total of more than 85% found suitable for inclusion in the National Wilderness Preservation System (NWPS) the National Park Service is fundamentally a *wilderness preservation* agency. The agency is also the pre-eminent keeper of our incredibly complex cultural heritage. Anachronisms are us!

On the subcontinent of Alaska, the Alaska National Interest Lands Conservation Act (ANILCA) of 1980 enlarged the NWPS by over 62%. The 8.4-million-acre Gates of the Arctic National Park and Preserve embraces 7.2 million acres of designated wilderness, with another million acres studied and deemed suitable. That's about 18% of the wilderness in the entire National Park System. Looking west to the adjacent Noatak National Preserve adds 5.7 million acres, bringing the total designated wilderness to nearly 13 million acres. When fused with neighboring parks, preserves, and refuges, nearly 39 million acres of Arctic wildlands, spanning the northernmost major mountain range on earth, are set aside as a physical embodiment of unparalleled wildness and naturalness.

And what about this fabled ANILCA wilderness? We often hear talk about big "W" and little "w," "landmark legislation seriously compromised by unacceptable use provisions," and "illusions of wilderness" from our allies! Suffice it to say that the detractors are many and their comments much more colorful. But most of that is pretty superficial in my mind. We have unheralded opportunities to achieve the greater public good in these large, intact northern biotic systems precisely because they are meant to be inclusive of, and imbued with, human culture. Biomes that still blur the arbitrary distinctions between people and nature. Human associations of nearly infinite variety. Verbal. Symbolic. Sensory. Physical. Mythic. Spiritual. Landscapes as a mutable stage for rich living traditions, cultural time capsules from the past, and human oral histories that continue to evolve. Infinite meaning in "empty landscapes" (Brown 2000)—whether we are ready to recognize it or not.

This opportunity necessitates creative and unconventional agency management strategies. Unique solutions for unique challenges. We have made some real progress in fulfilling the dream of preserving an Arctic heritage in an unconventional way. But it is daunting to realize how much more we must accomplish before the crush of human needs reaches the Brooks Range, as it certainly will.

In the last decade at conferences like this the academic debates on the meaning of wilderness seem mind-numbing and artificial. Orwellian double-speak comes to mind. In thousands of pages of convoluted text the "post-modern deconstructionists" have reminded us that reality is always culturally framed, that the wilderness idea is a social construct, and that there are many perspectives on the meanings of wilderness. Another Blinding Flash of the Obvious!

You know the charges. Standard bearers for this polemic describe the "received" wilderness idea as "ethnocentric, androcentric, phallocentric, unscientific, unphilosophic, impolitic, outmoded, even genocidal" (Callicott 1998)! In Alaska, urban rednecks just call it a lock-up!

It is also true in Alaska that many people are closer to real nature and know that wildness is a biophysical reality—far more than some "philosophical torturing" of concepts. The land base is the referent reality; rural people in Alaska know this (Brown 2000). And ANILCA reflects this reality in allowing traditional uses, in maintaining a human face on the wildest landscapes we know.

Much of the academic debate sounds like self-serving nit-picking by people whose finger nails are far too clean. After all, the world of park management is based almost entirely upon social constructs in the form of laws, policies, and scientific theories about the natural world and human history. The wilderness idea as embodied in law is indeed a social construct. Right along with the National Historic Preservation and the Civil Rights acts.

Wilderness is often an illusion precisely because its value is in the eye of the beholder. So social hindsight and scientific insight necessarily redefine the reasons for conservation. How could it be otherwise? Although there are many socially redeeming reasons for conserving a system of protected areas—from the spiritual to the aesthetic to utility to sanctuary—it is the reconnection with our original nature in a primordial setting that without fail inspires people. As Dave Foreman and others say, wilderness is simply a "self-willed land". A key phrase in the Wilderness Act is "untrammeled." So many detractors purposely misconstrue that to mean "untrampled" or "untrodden." The term simply means "unfettered," "unhobbled" and "unrestrained." A landscape that endures precisely as a result of sustainable human associations and practices.

So let's talk about a different way of seeing the Gates of the Arctic wilderness and focus on something we can change. Re-framing the wilderness question can reduce the *internal* threats to the wilderness resource from the disintegrated NPS approach. Perhaps thinking of wilderness as a cultural landscape would reduce organizational barriers and increase the comfort level with the need for collective restraint. I think organizational subcultures, program separation, and the quasi-military structure of NPS have created serious barriers to success on the ground, in the mind, and among disciplines. Internal agency rhetoric and actions are often at cross-purposes and result in greater public confusion about the enduring benefits of wild places, as well as falling far short of stewardship. The benefit of an integrated approach to an overarching legal responsibility such as wilderness preservation is a shared sense of what appropriate human behaviors are in such a place. Restraint is the key.

Is this a novel criticism of reluctant stewardship? No, but if repeated often enough perhaps we can find a synthesis of expertise and raise the level of agency discussion. We've heard repeatedly about the seminal findings of previous NPS wilderness task groups since 1986—findings that have mostly been ignored. And re-described by the next task group. But one important idea—that of a national wilderness steering committee—finally took root in 1996 and is bearing sweet fruit. As discussed in plenary conference panels earlier this week, this committee's energy has resulted in the excellent stewardship policies and guidelines embodied in Director's Order #41. Not perfect by any means, but they are a quantum leap forward for NPS. And they clearly respond to the many understandable concerns of cultural resource specialists and others always complaining about isolation from the management of wilderness.

New NPS policies are unequivocal in speaking to the cultural values found in wilderness. "There has been extensive prior human use in most areas now designated as wilderness, resulting in archeological sites, historic structures, cultural landscapes and associated features, objects, and traditional cultural properties that are contributing elements to wilderness." We are appropriately reminded that the suite of laws intended to preserve our invaluable cultural heritage, such as the National

Historic Preservation Act, are applicable in wilderness. The steering committee reminds managers that cultural resource specialists (along with all other disciplines in interdisciplinary teams) will participate in wilderness planning and that managers are responsible for maintaining an affirmative cultural resource management program in wilderness. It is important to note that the directive makes absolutely clear that even though "cultural resource management tasks within wilderness are the same as those elsewhere, these sites must be additionally treated in a manner that preserves other *wilderness resources and character*" (emphasis added)**.** Measures to protect and inventory cultural resources in wilderness must comply with the Wilderness Act provisions on access and the use of the minimum requirement concept. The importance of this last reality check is inestimable.

In NPS parlance, a cultural landscape is defined as "a geographic area, including both cultural and natural resources and the wildlife or domestic animals therein, associated with a historic event, activity or person, or that exhibit other cultural or aesthetic values." There are at least 4 general types of cultural landscapes that are not mutually exclusive: historic designed landscapes , historic vernacular landscapes, historic sites, and ethnographic landscapes (NPS 2000). The concept has evolved greatly from the limited inclusion of the grounds immediately surrounding a historic structure and tangible features described in the 1960s.

The central idea embodied in ANILCA is that the long cultural traditions of indigenous groups and more recent immigrants are subtle and complex historic associations with a vast wild region in the central Brooks Range. It seems to me that at least the categories of "historic vernacular landscapes" and "ethnographic landscapes" could be construed to describe the human associations of Gates of the Arctic wilderness. I suppose that hard-core cultural specialists will claim that cultural landscapes are by definition limited to an area containing associated features, and that those cultural features are human "built" scenes. But I think that the wilderness idea embodied here is a cohering social construct inclusive of many vibrant human associations. Just for starters, how about the inclusion of the vast headwater valleys and ragged peaks where Bob Marshall found inspiration, and its seminal influence on the eventual formation of the Wilderness Society and passage of the Wilderness Act in 1964? Then there is the austere homeland of the recently nomadic Nunamiut and hinterland of other adjacent Alaska native groups and their predecessors. And what of meanings derived from sledge-hauling geologists, tump-line-weary prospectors, military expeditions living off the land, old-time, fair-chase, wall-tent hunting guides, backpacking field biologists of the Murie era, and solitary cabin dwellers more recently seeking respite from modern society?

Gates of the Arctic is a vibrant reflection of what was once the dominant feature of a thinly peopled world precisely because it remains unbuilt and untrammeled. A heritage cultural landscape. A reservoir of answers for questions we have not yet thought of about the dynamic nature of the natural world and human adaptations and responses. "Relevance is mostly organized around function" (Brown 2001).

This is a repository of sustainable lifeways, abiding understanding of Arctic life, and reminders of the eons of simple relationships that stands in stark contrast to our modern ways. So I see conceptual advantages and potential program coherence in treating the Gates of the Arctic wilderness as a complex cultural landscape. The increased opportunities for collaborative planning, the ease of incorporation of traditional knowledge, and reducing the public misconceptions through more easily understandable relevance are reasons enough to consider embracing this notion.

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48 Viewing the Civil War through a natural resource window

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Our understanding of history is enriched by trying to view the events from as many perspectives as possible. An example of an unlikely linkage is geology's influence on the campaigns and battlefields of the American Civil War. Geology has an important role in shaping the terrain, and terrain is critical to any military venture. Both Union and Confederates used, or in some cases failed to use, terrain to their benefit in choosing defensive positions, maneuvering troops, and selecting supply and communication routes. In some instances, commanders had common knowledge of geology and geologic processes and employed it to their military advantage. Through the use of three examples from the Civil War, we can reach across the boundaries of history and science.

Vicksburg

The Mississippi River was important in the Civil War. It divided the country, east from west. It was a major transportation route. Geologic processes are continually at work shaping the river's course and carving out the surrounding landscape, be it bluff, beaches, natural levies, or swamps. New channels were cut , and old ones abandoned, by the Mississippi.

During the Civil War, Confederate forces closed the river to navigation. This threatened to strangle northern commercial interests. President Lincoln felt that Vicksburg was of great importance for Union control of the lower Mississippi River and the key to ending the war. By taking control of Vicksburg and the lower Mississippi, it would split the South in two and sever a vital Confederate supply line. Within the city limits of Vicksburg as well as the surrounding forts, fortifications along the bluffs of the river were impregnable. Direct attack was considered impossible; maneuver and small attacks provided no results.

In the summer of 1862, a 3,000-man infantry brigade commanded by Brigadier General Thomas Williams began construction on a canal at the Tuscumbia Bend on the Mississippi River. It was situated at the location of an earlier canal south of Vicksburg that bypassed the city. It was hoped that the canal would divert the main river flow away from the large meander-loop channel located on the waterfront of Vicksburg. The Union commanders speculated that if the scouring effects of the Mississippi were strong enough, it would change the river's course, leaving the city high and dry and making it militarily worthless.

Canal construction began on June 27, 1862. Union soldiers felled trees and excavated soils. Progress was slow, so slave labor was added to the workforce. Unfortunately, all manner of disease took its toll on the labor force. Work on the canal was halted on July 24th so that Williams and his soldiers could take part in military operations.

In January 1863, work on the canal was resumed by troops under the command of Major General Ulysses S. Grant. He approved the idea, believing it would keep his soldiers in good physical condition for the spring campaign and, more important,

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keep the spirit of the offensive alive, but he placed little confidence in the success of this project. On almost a daily basis, President Abraham Lincoln inquired about the progress of the canal. In a previous career Lincoln was a land surveyor, so he was enthralled with the scheme, and Grant always provided him with a somewhat optimistic reply.

The soldiers and the slaves who had been pressed into service continued to excavate. A sudden rise in the river caused a dam at the head of the canal to break. The area was flooded, and the canal filled with water and sediment. In a desperate attempt to rescue the project, Hercules and Sampson, two huge steam-driven dipper dredges, were put to work clearing the channel. Confederate artillery fire from the bluffs at Vicksburg drove out the dredges. By late March, Grant decided to abandon all operations on the canal.

Within a few years, the Mississippi River naturally diverted to a new channel that was located close to the Williams-Grant canal location. This event isolated Vicksburg from the main river and its traffic. It gave validity to the concept of mimicking the natural geologic processes by inducing a meander cut-off by digging a canal. Over the years, most of the canal has been obliterated through agricultural operations, and only one segment retains its original width and much of its depth. In recent times, the U.S. Army Corps of Engineers dredged a connection to the old channel that existed in 1863. Today, the Mississippi River flows past Vicksburg once again (Figure 48.1).

Gettysburg

For two bloody years (1861-1863) the Union and Confederate armies had fought to a standstill in the countryside between Washington and Richmond, the two capitols. Another entire campaign was fought to a standstill in 1862 on a peninsula of coastal lowland southeast of Richmond. In the summer of 1863, the two armies faced each other across the Rappahannock–Rapidan rivers defense line. General Robert E. Lee decided to make a move to bring the war to the North and, he hoped, end it.

The Gettysburg campaign took place in four geologic provinces, running roughly parallel lengthwise from northeast to southwest. From southeast to northwest they are: (1) the Piedmont, (2) Mesozoic (Triassic) basins, (3) the Blue Ridge, and (4) the Valley and Ridge (Great Valley; Figure 48.2). Each province had advantages and disadvantages for a military campaign. The Piedmont was hard for armies to move through and favored the defenders. The Triassic basins had better roads, but rock outcrops restricted maneuverability. The Blue Ridge was a mountain barrier, impassable to armies except through the mountain gaps. The Great Valley, the first in the Valley and Ridge province, was the interstate highway of the time. Broad, flat valleys made for easy transport and excellent troop movement.

Troop movement and geology. The Gettysburg campaign began on June 3, 1863, when the Army of Northern Virginia left Fredericksburg, Virginia, under the direction of Lee. The campaign started in the Piedmont; however, the armies left it as soon as possible. The exposed rocks, ridges, and ravines made for rough roads that were hard on troops, animals, and equipment. The only practical roads on which Lee's Army could move north were by way of the Culpepper basin toward the high and narrow Blue Ridge. The Confederates would cross the rugged steep mountains through a series of gaps and into the Great Valley. The gaps are of great significance to the Gettysburg campaign because they were the passages by which armies could cross the Blue Ridge. The mountains of the Blue Ridge were equally important because they shielded the Confederates from view by the Union Army.

Skillful use of the terrain to move the 80,000-man Confederate army with all its equipment and supplies into enemy territory, almost unseen and unhampered, was a hallmark of the Gettysburg campaign. The geologic processes that faulted, widened, and sculpted the Cashtown Gap in the mountains of Pennsylvania made it the only possible route for Lee's army to concentrate and move swiftly through the mountains, all at one time, to attack Union targets. The gap destined Lee's army to pass through Gettysburg (Figure 48.3).

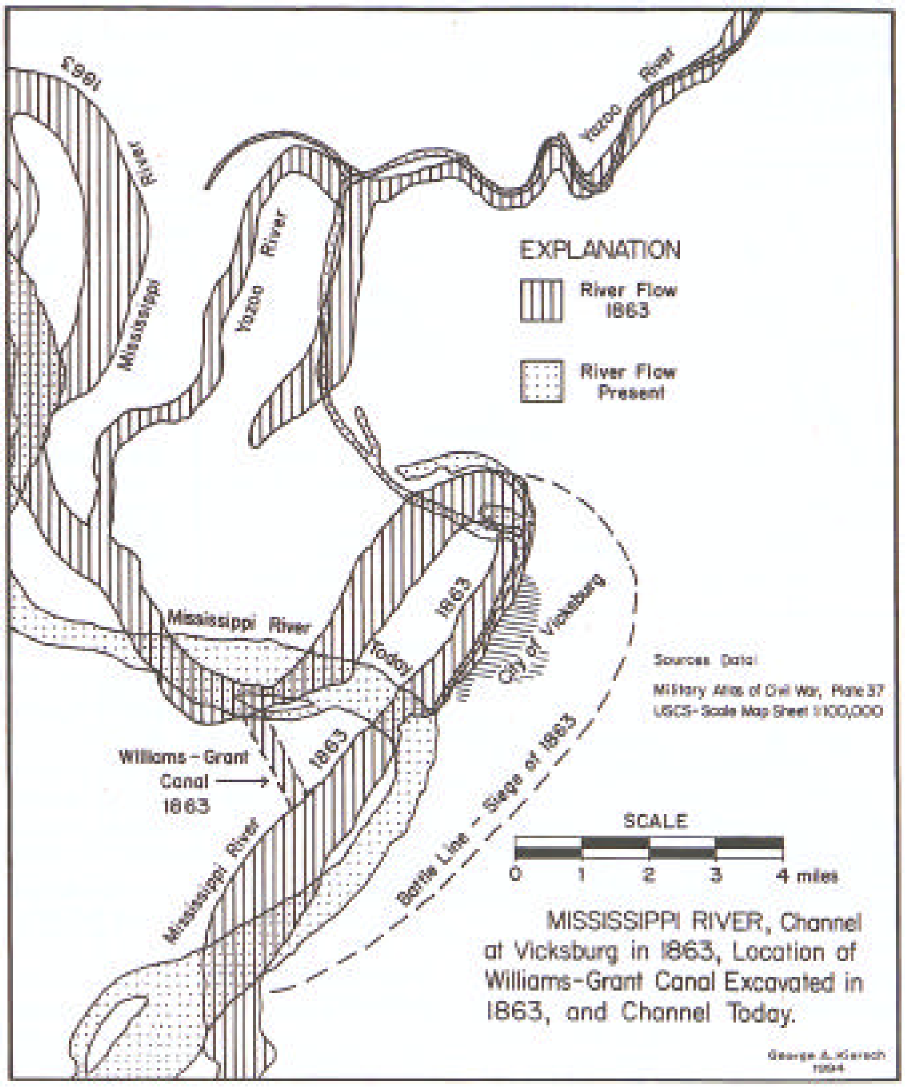

Figure 48.1. U.S. Army Corps of Engineers map of the Williams-Grant Canal and the change in the Mississippi River.

While Lee was moving northeast in the protected valley, General George G. Meade was setting up a strong defensive position east of Gettysburg on Parr's Ridge. This position, in the Piedmont province, provided an excellent defensive position.

Battlefield. The battle involved three fierce days of fighting. The first day, July 1, 1863, involved elements of both armies stumbling into one another north of the town of Gettysburg. The Union forces were outnumbered and fell back while both commanders were desperately trying to reinforce their combatant troops. At the end of that day, the Union army had the best field position, which was essentially located along Gettysburg sill, an outcrop of diabase. The outcrop is shaped like a fishhook and extends northward for approximately there miles from Round Top through Little Round Top and Cemetery Ridge to Cemetery Hill. Then, it turns east and south and terminates at Culps Hill. General Lee surveyed the strong Union position and occupied the next best position along Seminary Ridge, which is a diabase dike, an offshoot of the westward-dipping Gettysburg sill. On the second day, July 2, the Confederates attacked the flanks of the Union line. The left flank did not appear to be anchored to any significant feature, so Lee surmised that this was a weak point in the Union position. He then launched a series of attacks against the southern end of the Union line in the vicinity of the Round Tops. The natural defenses provided by rock outcrops and boulders at Cemetery Hill, the Round Tops, and Devils Den proved to be stronger than Lee thought, and the Confederates were unsuccessful. The final day of battle, July 3, would culminate in Lee's attempt to break the Union center by one final assault, known as Pickett's Charge. The charge on Cemetery Ridge failed, and the Union army held its position.

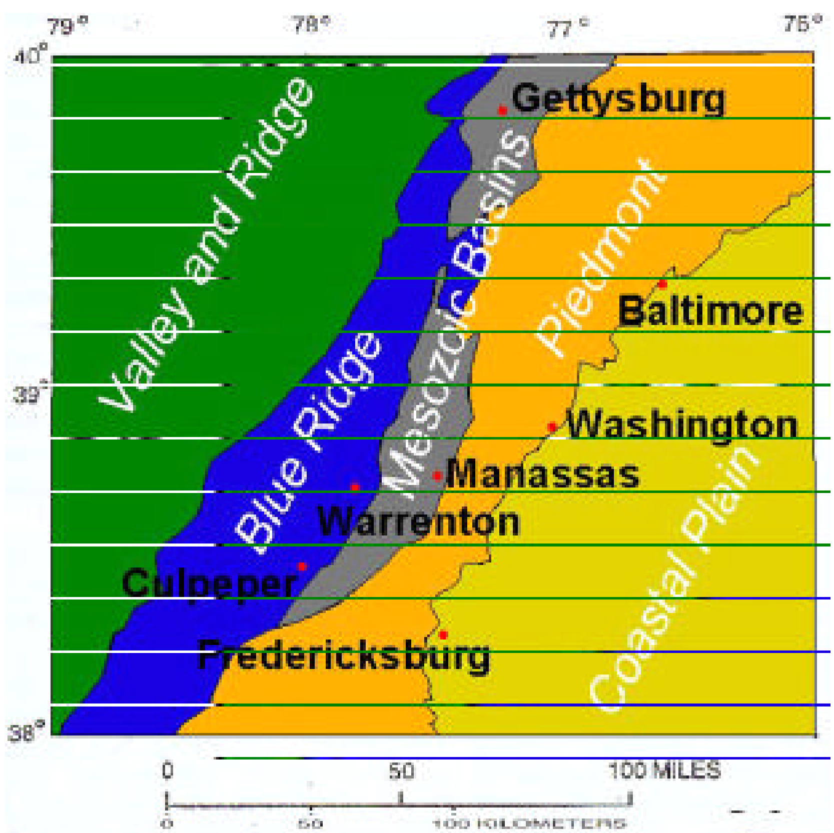

Figure 48.2. Geologic provinces in the Gettysburg campaign.

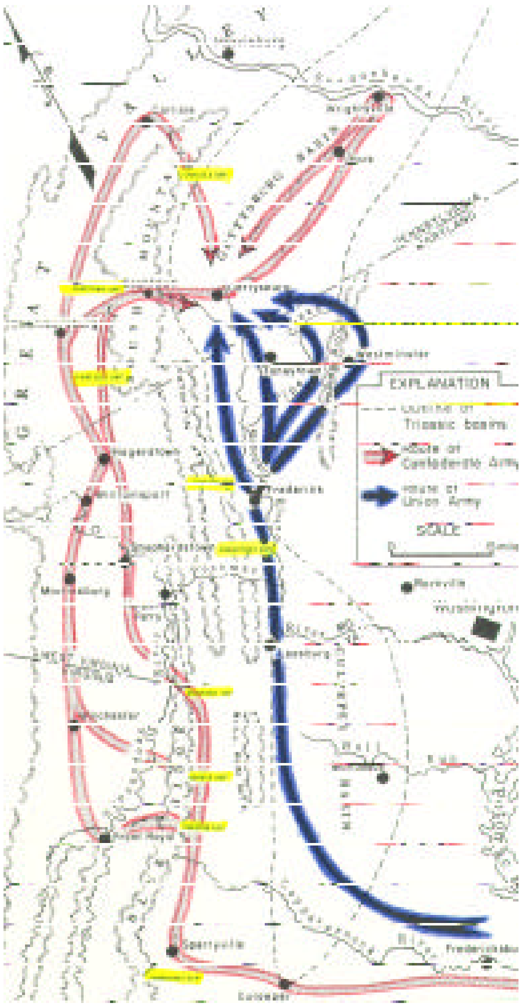

Figure 48.3. Using gaps and getting to Gettysburg.

The Union army suffered 23,000 casualties, while the Confederates lost 28,000. The numbers are disproportionate, given that the Union army was the defending force in the battle. In previous battles, the defender would normally be entrenched and had a 1:2 advantage and, in some cases, as high as 1:4. The Union position had a weakness that became more apparent as the battle progressed. Owing to the local geology, the resistant diabase sill had very little overburden. It was virtually impossible for the Union soldiers to "dig in" and the only protection provided was by existing stone walls, outcrops such as Devils Den, and isolated boulders.

Under storm clouds and heavy rain, the end of the battle signaled a retreat by Lee and the Confederate army back to Virginia. Within a matter of weeks, both armies were on the Rappahannock–Rapidan rivers defense line where they had started June 3, 1863.

Petersburg

Petersburg is situated on the south bank of the Appomattox River in a geologic area know as the Prince George upland. The city of Petersburg was important to the Confederate army because of its relationship with Richmond's supply lines. Three important rail lines converged at the city, as did two important roads that linked Petersburg with the region to the south and southwest. The Siege of Petersburg was part of a strategy by General Grant. He wanted to force General Lee to extend and thin his lines in an attempt to prevent the Union from cutting off vital communications. The Siege of Petersburg was the longest of the Civil War, lasting more than nine months.

In June 1864, an extensive system of trenches and forts had been constructed along the eastern side of Petersburg at a distance of more than four miles. The two armies were separated by a siege line that was 500-1,000 feet wide. Just west of Poor Creek, the line's width narrowed to a distance of approximately 250 feet. These lines remained fairly stationary for the next nine months. Colonel Henry Pleasants was in command of a brigade that held the Union position opposite the Confederates at this closest point along the line. A professional mining engineer in Pennsylvania before the war, Colonel Pleasants conceived the idea of digging a mine from his regiment's position to the west of Poor Creek under a Confederate fort. Pleasants contended that by filling the end of the mine tunnel with a series of magazines of black powder, a tremendous hole could be blown in the rebel line. This would allow the Union army to rush through the opening and drive the Confederates out of Petersburg. With support for his plan from the commander, he began to mine.

The excavation of the tunnel went well for the first 200 feet. At this point, the miners encountered "marl," which was extremely difficult to excavate. Pleasants ordered the tunnel to be ramped slightly upward for approximately 20 feet into less-resistant material. The final tunnel excavation brought the end to within 20 vertical feet of the Confederate fort.

At 4:45 AM on July 30, the mine was exploded. A 200 foot-wide gap was created in the Confederate line and numerous Union soldiers were sent into the crater. The tunnel was an engineering success, but the poorly led Union soldiers headed into the crater and not around it, as planned. The Union outnumbered the Confederates, yet they were unable to advance from the crater or easily retreat. At 9:30 AM, the attack was called off and there was to be no more support to the Union soldiers in the crater. The gap was sealed by the Confederates, and they slowly advanced on the crater. The Union troops, who still outnumbered the Confederates, were forced to surrender. The best chance for ending the Siege of Petersburg had instead become a symbol of military debacle. After ten hours of fighting and the combined loss of nearly 6,000 lives, nothing had tactically changed.

Since the Battle of the Crater in 1864, there has been much speculation concerning the geologic strata encountered in the tunnel. It was fortunate that the Union commander and the miners who dug the tunnel had enough knowledge of geology from their experience in the coal mines of Pennsylvania to know how to react to the change in conditions.

Due to the presence of the Dutch Gap fault zone, it had been speculated that the Union miners had encountered a fault while digging the tunnel. In addition, previous publications had suggested that excavation of the tunnel was through the Eastover formation. In August 2000, the National Park Service's Geologic Resources Division and the Virginia Geological Survey investigated the geologic reason for the difficulty that Pleasants's men encountered while excavating the tunnel. The investigation used a four-inch auger drill to interpret the geologic units of the site (Figure 48.4). Two holes were drilled adjacent to the tunnel at the Crater. Using the information, geologists produced a geologic cross-section.

Drilling confirmed that tunneling took place in the Yorktown formation. The Yorktown formation consists of rock strata that are 3-5 million years old, with the lower formation consisting of marine deposits that include quartz pebbles and cobbles, shark teeth, coral, and very fine-to-medium sand-sized shell debris. The "marl" encountered by the Union troops has now been confirmed to be an abandoned channel deposit located in the upper Yorktown formation. The abandoned channel formed an oxbow lake, filled with extremely fine-grained material and consisting of dense sticky clay. The abandoned channel deposit found during the drill investigation was located precisely at the level where the Union soldiers reported having great difficulty excavating. The Eastover formation was found in the drill hole at approximately 10 feet below the tunnel (Figure 48.5). The geologic puzzle that influenced the military operation was solved.

Figure 48.4. Drilling for geology to solve the puzzle.

Conclusion

The Battle of Vicksburg, the Battle of Gettysburg, and the Battle of the Crater were events greatly influenced by the areas' geology. By adding this information, we gain a better understanding of the circumstances of events, and we enrich the telling of the Civil War Story.

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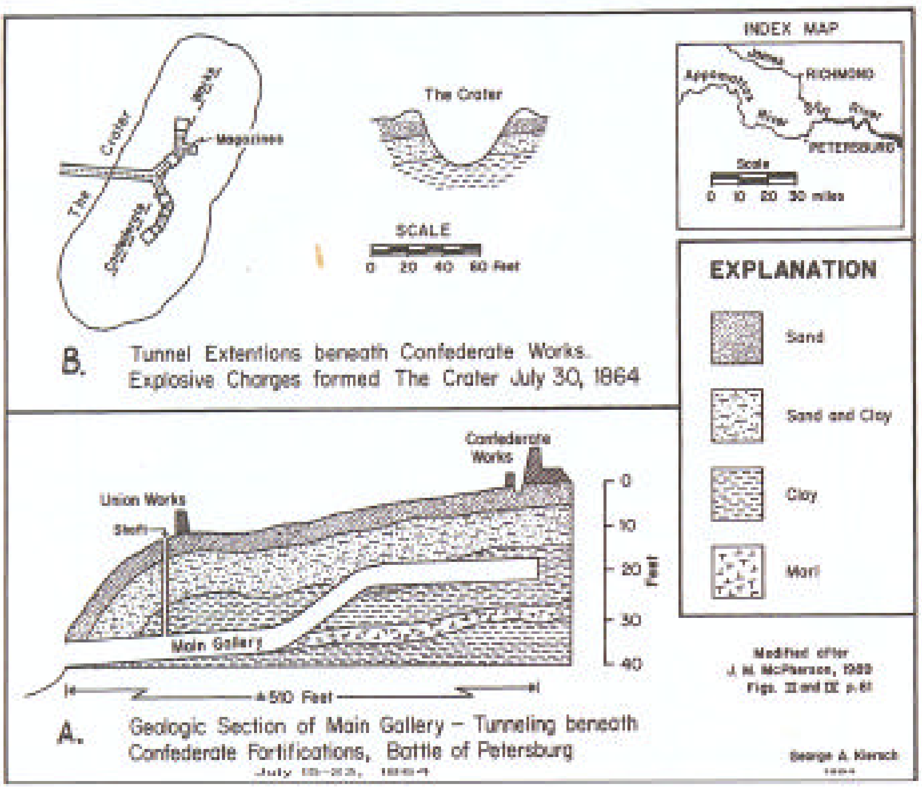

Figure 48.5. U.S. Army Corps of Engineers schematic of the tunnel at Battle of the Crater.

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49 Integrating NHPA section 106 compliance and prescribed fire: a model

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In recent years, fire managers at Grand Canyon National Park have adopted an aggressive prescribed fire program. Burn units have grown from small blocks of a few hundred acres to large, landscape units encompassing thousands of acres. Annual burn acreage increased exponentially, from 1,550 acres in 1997 to nearly 10,000 acres in 2000.

Section 106 of the National Historic Preservation Act (NHPA) and its implementing legislation and guidelines directs land managers to consider the effects of their undertakings on cultural resources. In order to assess effects, resource managers must know the resources and possible effects on them. Currently, only about 3% of the land managed by Grand Canyon National Park has been systematically surveyed for cultural resources sites. Consequently, resource inventories are often needed as a part of the section 106 compliance process. The rapidly increasing prescribed fire acreage overwhelmed archeologists trying to complete inventories for NHPA section 106 assessments. In spite of the challenges presented in completing NHPA compliance for such a large prescribed fire program, the prescribed fire archaeology program at Grand Canyon has come to serve as a model.

Recognizing the need

To ensure the timely completion of NHPA section 106 compliance, fire managers at the park included an archeologists' salary in FIREPRO funding requests. The program has grown from a seasonal archeological technician funded for a few months in 1994 to include one archeologist and three archeological technicians working year-round.

In 1998, Grand Canyon prescribed fire managers recognized the enormous workload created in completing NHPA section 106 compliance for thousands of acres. The amount of work required was beyond what could be accomplished by the single archaeologist funded by park operational funds. Accordingly, they began funding an archaeologist and three archaeological technicians in term, subject-to-furlough positions rather than simply for the summer season. Recognizing the ongoing need for NHPA compliance, the archaeologist was converted to a permanent, subject-to-furlough position in 2001.

The chief of cultural resources supervises the archaeologist and archaeology crew, whose offices are in the park's science center, which houses resource management staff. However, prescribed fire staff determine work priorities. Essentially, cultural resource managers assure that work meets the appropriate standards, while prescribed fire staff dictate the work schedule.

The critical elements for this program's success are planning, communication, and respect. Through careful planning and close coordination, cultural resource managers and prescribed fire managers can assure that the objectives of both disciplines are met.

Planning

Careful planning by both the prescribed fire manager and the archaeologist assures that work priorities are established and followed. Prescribed fire managers

From **Crossing Boundaries in Park Management: Proceedings of the 11th Conference on Research and Resource Management in Parks and on Public Lands,** edited by David Harmon (Hancock, Michigan: The George Wright Society, 2001).

clearly articulate their priorities for the coming year and the next five years. These priorities dictate the work for the archaeologists. Each October, the archaeologist develops an annual work plan, which describes goals for the project, outlines what projects will be the completed in the coming year, and estimates the time and cost to complete projects. The archaeologist prepares the annual work plan and the prescribed fire manager, fire management officer, and chief of cultural resources review and approve the plan. As prescribed fire priorities or projected timelines change, the annual work plan is amended. The annual work plan serves as a contract between the archaeologists and prescribed fire staff, articulating the commitments made by each party and ensuring that the program remains "honest," that is, the archaeologists actually work on prescribed fire projects, not other tasks.

An end-of-the-year accomplishments report details how the crew carried out the annual work plan. This report describes goals met, projects completed, acres surveyed, and costs for the program. In recent years, costs ranged from $3 to $36 per project acre and $10 to $50 per survey acre. Project and survey costs per acre may vary at other parks, because the crew at Grand Canyon does sample and judgmental surveys rather than 100% coverage for most prescribed fire projects. This allows archaeologists to obtain an estimation of site types and densities and do further surveys as necessary. For example, in high elevations on the North Rim, judgmental surveys are completed where historic sites are likely to occur and the remainder of the unit is sampled to estimate overall site types and densities. In one area of the South Rim, a sample survey revealed a number of Navajo and Havasupai sites such as wickiups, corrals, and sweat lodges. To assure that these resources were located, documented, and protected, the selective survey was increased to a 100% survey for this project.

In the first couple of years of this program, archaeologists were scrambling to complete projects in time for preferred "burn windows." It was not uncommon for project implementation to be delayed because NHPA compliance was not complete. In the last year, archaeologists have begun to get section 106 inventories completed a year or two before project implementation dates. This allows for a more efficient use of crew time and better protection of cultural resources. For example, in the past two years the archaeology crew has focused on fieldwork during the summer season and used the winter for data processing and report preparation. Previously, crews were so rushed to complete projects that much data processing and report writing occurred in the summer and we tried to complete fieldwork in the winter.

Communication

To ensure that work is completed following prescribed fire priorities, and to maintain integrity in the program, close communication is maintained between the archaeologists and prescribed fire staff. This is accomplished through many means: quarterly meetings between prescribed fire managers, the cultural resource manager, and the archaeologist; monthly written and telephone updates; and written planning documents. Documents include annual work plans, survey plans, and yearly summaries of accomplishments. These planning documents allow work to be clearly laid out and articulated and costs and accomplishments accurately summarized. Careful record keeping provides integrity for the program. Crew time and expenses are closely tracked, allowing for a detailed accounting of time and money.

Careful planning and communication also lead to better cultural resource protection during prescribed fire implementation. Prescribed fire managers include cultural resource preservation as an objective for each project. Archaeologists identify which sites have the potential to be affected by the proposed prescribed fire project, whether it is fuel piling and burning within a prehistoric artifact scatter or burning near a historic cabin. Prescribed fire staff and archaeologists work together to identify methods to protect sites and assure no effects occur.

For example, to accomplish landscape-scale burns, fire managers use aerial ignition extensively. This ignition method presented new challenges in resource protection since personnel are not allowed within burn areas during ignition. In some units, sites with combustible elements were within areas to be aerially ignited. To protect these sites, a combination of pre-treating and thorough marking aided in site protection. Protective measures include lining sites, limbing trees, and manually removing fuel from sites or features. Archaeologists and fire staff developed a system of aerial "non-targets" to mark site areas so they can be seen from the air. Ignition bosses were supplied with maps of sensitive resources and ignition ceased within these areas. Additionally, archaeologists are usually on-scene during prescribed fire implementation. They attend crew briefings and work with the on-the-ground firefighters. This helps convey the importance of cultural resources and assures that cultural resource preservation remains a priority. This is especially beneficial when working with crews from other park units or agencies that may be unfamiliar with Grand Canyon's resources.

When cultural resource preservation is included as a prescribed fire objective, post-fire site visits are needed to ensure that the objective is met. Currently, the archaeology crew revisits sites identified as having the potential to be adversely impacted by the project. No new inventory survey is completed post-fire. A post-fire assessment report is completed to document the protection measures used and judge their effectiveness.

Respect

Inherent in this program is a recognition of and respect for the resources, and for those who seek to protect them. Prescribed fire managers must recognize the value of cultural resources and understand cultural resource preservation law. At the same time, cultural resource staff need to appreciate that fire is a powerful, science-based resource management tool.

Discussion

At Grand Canyon National Park, the prescribed fire archaeology program has been an outstanding success from the perspectives of both cultural resource managers and fire staff. Cultural resources are identified and preserved and burn objectives are met. Planning, communication and respect are the keys to success.

50 Resource stewardship—rebuilding a house divided: the Pacific West Region's resource stewardship strategy for 2000 and beyond

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An overview

Much has been written about the need to better care for resources in the U.S. national parks. The Leopold Report, the Vail Agenda, reports from the Government Accounting Office, the Pacific West Region's white paper "The Resource Protection Dilemma," and NPS Historian Richard West Sellars' recent book *Preserving Nature in the National Parks* all point out the shortfalls in the Park Service's resource protection and management programs.

The NPS strategic plan lists resource preservation as the first of four goals toward which we are striving. "Easy access has created a complicated challenge: how to adequately protect and preserve park ... resources while providing safe and enjoyable experiences for the public and visitors. Easy access and commercially desirable resources, combined with a limited ranger force, have resulted in increased resource crimes, including poaching, archeological theft and grave robbing, which often go undetected until too late.... The National Park Service must strive to further protect and preserve our nation's natural and cultural resources. Public support of all environmental and cultural laws must be reflected in budget and staffing allocations" (p. 45).

NPS continues to have great difficulty addressing the burgeoning resource protection dilemma that includes commercialized plant and wildlife poaching, archaeological resource theft, paleontological and geologic resource theft, and other environmental crimes. The reasons for this apparent inability to protect the park resources are varied. Visitation to NPS areas has grown so rapidly over the last twenty years that park protection staffs have been hard-pressed to deal with the increasing law enforcement and emergency service demands. NPS supervisors and managers have placed higher priority on quality emergency services. Consequently, attention to the protection of resources became something that was done when rangers weren't busy caring for, or dealing with, visitors.

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Increased demands for natural resources have further compounded the situation. Rapid human population growth, especially in Third World countries, created increased demand for animal parts and plants for medicinal and aphrodisiac purposes. This one aspect alone has focused profit-driven poachers on national parks, where they take bears, ungulates, and various plants to supply a burgeoning black market. In addition, trophy hunting and worldwide demand for archaeological, paleontological, and cultural artifacts have added huge incentives for criminals to exploit park resources. The U.S. Fish and Wildlife Service estimates the illegal wildlife trade in the USA to be second only to the illegal drug trade.

Over the last fifteen years, NPS has responded to the increase in resource management complexity through various initiatives that have created a specialized pool of employees whose primary responsibility is resource management. In the wake of this specialization, the role of the protection ranger became unclear. Eventually rangers became more and more like public safety officers and emergency service providers, and their resource management and resource protection skills waned. Also during this time, a schism began to develop between rangers and resource management staffs that tended to alienate the two groups from one another, with neither fully appreciating the work of the other.

We now understand that resource management and resource protection are equally important elements to effective resource stewardship. NPS is mandated by law to preserve resources for the enjoyment of present and future generations. It is an awesome, and, at times, conflicting task, but according to agency policy, recent court decisions, and the NPS director's stated priorities, NPS must assure the protection of the resources entrusted to it as "the" highest priority.

The recently implemented Natural Resource Challenge (NRC) calls for revising the resource management planning process to better integrate it into general park planning, and for involving all park divisions in its development. Techniques are to be developed and employed that protect the inherent qualities of national parks and restore natural systems that have been degraded. Collaboration is necessary with the public and private sectors to minimize degradation. One of the challenges in the NRC is to *protect* native species and their habitats. There are many opportunities for resource managers, protection rangers, and all park employees to work collaboratively on such projects as non-native species control or carrying out the provisions of threatened and endangered species recovery plans.

Another NRC section challenges NPS to provide leadership for a healthy environment, including air and water resource protection where joint planning can be conducted for hazardous materials spill response, monitoring, detection, and mitigation of pollution sources. Finally, the NRC indicates that the "foundations of stewardship" will ensure that professional development programs for resource managers, rangers, and park managers will be strengthened, and will also be expanded to ensure that all employees have adequate understanding of park resources to contribute effectively to the mission.

Resource protection is the responsibility of every NPS employee, not just the resource management specialist or the protection ranger. All employees need to be given clear direction about the importance of their roles as resource protectors.

Integrated strategies to improve the protection of NPS resources need to be developed under the tenets of "resource stewardship." For the purposes of these strategies, "resource stewardship" is defined as the collective efforts of all park divisions to preserve, protect, maintain, restore, and understand park resources. This integration and synthesis of work by all park employees should result in greater preservation of resources in perpetuity. Under this tenet, other disciplines can easily assume their role and place of importance to make NPS a better resource steward.

Collaboration is the key in developing resource protection strategies at all levels of the organization from the park through upper-level management in regional and Washington offices. Park resource management plans and other site-specific plans must reflect the interdisciplinary nature of the work that needs to be done to protect resources. Regional management must make superintendents and members of the regional directorate understand this expectation and communicate the importance of protecting resources. Key regional staffers, along with their various advisory councils, must take a look at the strategies on the following pages and begin to set up systems that reward interdisciplinary thinking, planning, and implementation. Washington personnel must set the tone and example and lead the way to improvement through collaborative efforts.

There are numerous examples popping up throughout the Pacific West Region of successful resource protection efforts. Pacific West Region is already influencing NPS policy in the resource protection and stewardship arena. A few of these examples follow.

- The strategy report was prepared by an interdisciplinary group of resource and protection managers.
- The Northern California–Southern Oregon Subcluster resource protection strike team is currently in its third season and is enhancing the resource protection efforts in their areas. This focused, specially trained and equipped group of rangers from four parks has been utilized on a variety of challenging resource protection issues.
- Various advisory councils meet with each other, plan joint conferences, and update one another on an ongoing basis.
- An interdisciplinary resource protection course was put on in the fall of 1999. Students and instructors from a variety of disciplines, including natural and cultural resource managers, protection rangers, public affairs officers, and hazardous materials coordinators, trained with assistant U.S. Attorneys in a team-building learning environment. This course received rave reviews by all attendees.
- The ranger advisory council generated a white paper on resource protection shortfalls and called for an integrated approach to address the problem.
- Several parks report recently receiving substantial base-funding increases as a result of developing interdisciplinary, resource-related project proposals.
- The Pacific–Great Basin Support Office protection leader and Joshua Tree National Park chief ranger participated in the development of national protection ranger competencies, ensuring that resource protection was a major requirement for protection rangers. They also supported requiring resource protection and stewardship training of all employees.
- When reviewing the draft NPS management policies, the Pacific West Region strongly recommended that a dedicated resource protection chapter be developed.
- Numerous Pacific West Region chief rangers participated in the development of the Thomas Report, a report to Congress on the NPS Law Enforcement Program. Identified in the report was the NPS' inability to adequately protect natural and cultural resources; the majority of the recommendations identify what is needed to improve resource protection capabilities.

There is a growing awareness throughout the region and Servicewide that NPS is failing in its resource protection mandate. The product of this working group is an effort to encourage "more and better" resource protection efforts which cross disciplines. Coming to similar conclusions, several other regions are developing resource protection strategies as well.

The observation of William B. Morse of The Wildlife Management Institute nearly three decades ago remains valid in the new millennium:

> Too often, enforcement is looked upon as a necessary evil, even as an anachronism that must be accepted simply because it exists. Nothing can be further from

> the truth. Without adequate law enforcement, the finest research and management will have little or no effect in protecting the resources. Scientist and manager alike must realize that wildlife (and this could also be said for other resources as well) depends on three-way teamwork, and must help give enforcement the stature and tools it needs to operate. Enforcement officers tend to feel alienated to some degree because they are not always considered essential or professional. If law enforcement is to meet present, let alone future needs, it must receive administrative interest commensurate with ... its importance as a member of ... the team.

The recommendations in the full report lay out a wide range of strategies to allow the Pacific West Region to continue to improve its efforts at resource protection. By adopting them we can continue to lead by example. The work has only begun....

Summary

Resource protection is being forgotten. No one division or group seems to consider it as a core responsibility. Rangers are busy dealing with visitor service and emergency response issues while resource managers often tend to focus on understanding and restoring ecosystems. In the meantime, precious resources are being poached, commercialized, stolen and destroyed.

In this paper a variety of methods have been identified to rejuvenate resource protection while continuing to build and enhance other new and vital areas of emphasis. While the need for increased funding for specific resource protection functions is evident, significant progress is possible by changing the agency's culture from within, without necessarily waiting for additional funding.

Hiring the right people as protection rangers and resource managers may be the single most important action that can be taken to improve resource protection. Hiring rangers whose training and ability is limited to emergency services, or resource managers in key positions who are unable to view management outside their own areas of expertise, has contributed to the present dilemma. Personnel with cultural and natural science education, training, and experiences that are capable, and willing, to perform as members of interdisciplinary teams, should be the focus of recruitment and hiring.

The discussion on training suggests integrating resource protection in all orientation courses, resource management training, law enforcement refreshers, etc. The resource protection strategy team felt it is especially important that the basic law enforcement for land management agencies curriculum at the Federal Law Enforcement Training Center once again include a major emphasis on resource protection.

Collaboration on planning at all levels of NPS is critical to developing and implementing resource protection strategies. At the park level, from the general management plan through preparation of annual work plans, resource protection issues and strategies must be specifically identified and integrated. Effective resources management should integrate science, management, and protection.

Interdisciplinary plans, implemented by well-trained and well-informed employees at all levels of the organization, will ensure park resources are available for present and future generations to enjoy.

Note: This paper is only an excerpt of the introductory sections of the strategy report. A complete copy of the document may be downloaded from http://www.redw.nps.gov/pro/-pwr_resource_strategies.doc. The recommendations in this paper are the result of an interdisciplinary working group appointed by the National Park Service (NPS) Pacific West Region's natural resources advisory council and ranger advisory council. The work is in response to Regional Director John Reynolds' charge to these councils to develop strategies to improve the resource protection efforts within the Pacific West Region. A resource protection strategy team, comprising the authors, was created.

51 Determination of ecological boundaries for the establishment and management of Canadian national parks

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Guiding principles for the establishment of new national parks

When Parks Canada proposes boundaries for a potential national park, the agency's policy (dating from 1994) states that it will endeavor to establish a park with a size and configuration that takes into account a broad range of ecological and socioeconomic considerations. Six of the nine boundary factors listed in this provision focus on maximizing the park's ecological integrity, two address socioeconomic concerns, and the last one relates to Parks Canada's mandate to provide opportunities for public understanding and enjoyment. The first and third criteria tend to increase the size of the proposed park, whereas the second tends to make it smaller than it would be if it were based on ecological and educational values alone (Mondor 2000).

In most cases, the boundaries of Canadian national parks deviate from optimum ecological limits and present significant challenges to park managers. Whether the park boundaries cut across watersheds (e.g., Nahanni National Park, Fundy National Park), include only parts of an animal population's range (e.g., Prince Albert National Park, Riding Mountain National Park), or exhibit a high level of fragmentation (e.g., Prince Edward Island National Park, Point Pelee National Park), the intensity and costs of managing for ecological integrity significantly increase as the park boundaries deviate from ecological boundaries. In light of the revised Canada National Parks Act and the recommendations of the Panel on Ecological Integrity (Parks Canada 2000) to protect for ecological integrity, it becomes critical that newly established national parks aim for sound ecological boundaries or options therein.

Challenged by multiple land use types: the case of the proposed Manitoba Lowlands National Park

The creation of a new national park in the Manitoba lowlands natural region is a key step towards achieving the Government of Canada's commitment to protect representative examples of each of the nation's 39 national park natural regions. Following a feasibility process with the province and consultation with stakeholders, initial boundaries were proposed in 1996 and focused on large areas of relatively undeveloped lands in the northern part of the natural region (Figure 51.1). Concerns were expressed at the time, however, about the ability of the area to sustain ecological integrity. Minor additions were proposed in 1998 to improve representation of key features, but were not endorsed by the industry stakeholders and still did not fully address ecological concerns. This paper presents the approach used to re-examine the proposed boundaries of the Long Point component of the proposed Manitoba Lowlands National Park (Long Point 96), a summary of the results, and a discussion of the value of the analytical approach in light of ongoing negotiations over the status of the area.

From **Crossing Boundaries in Park Management: Proceedings of the 11th Conference on Research and Resource Management in Parks and on Public Lands,** edited by David Harmon (Hancock, Michigan: The George Wright Society, 2001).

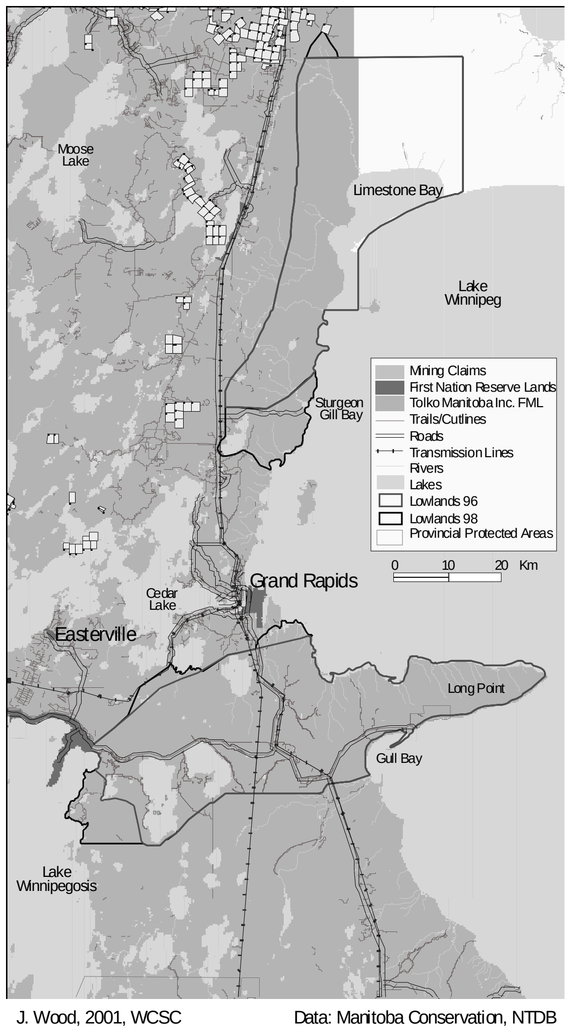

Figure 51.1. Proposed park boundaries for the Manitoba Lowlands National Park.

Delineation of ecological boundaries for the Long Point area

The analytical approach used to delineate ecological boundaries follows the process outlined in Figure 51.2 and is based on the parks' ecological goals and objectives of *representation* and *integrity:* representation, to ensure that the composition and abundance of native species and biological communities characteristic of the Manitoba lowlands natural region are reflected in the protected area; integrity, to ensure that ecological processes and populations of native species are allowed to evolve.

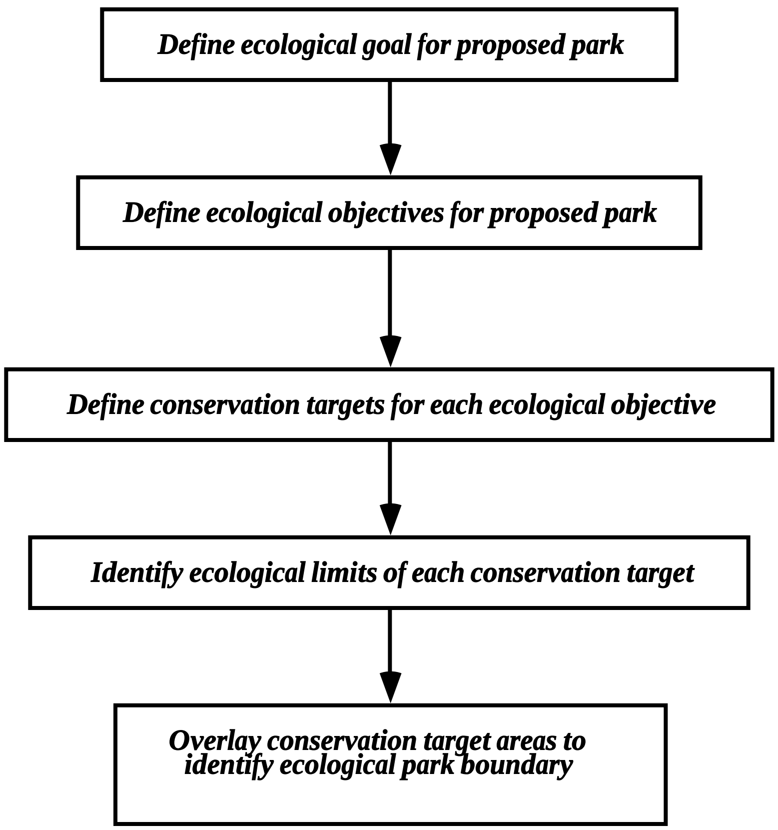

Figure 51.2. Process for defining ecologically sound park boundaries.

Based on the ecological objectives, conservation targets are developed at regional, coarse, and local scales and are used to assess the proposed park boundaries. If the proposed park boundaries fail to meet the conservation targets, new boundaries are identified based on the analysis of available information and best professional judgment (conservation target areas, or CTAs). These are then overlaid to depict the ecological boundaries of the proposed protected area.

Conservation targets and target area for each ecological objective

- ***Ecological objective 1:*** Represent the terrestrial and aquatic ecological systems that are characteristic of the Manitoba lowlands natural region, reflecting the composition and abundance of native species and biological communities.

"Representation," as applied to conservation, is a measure of the degree to which a protected area or system of protected areas portrays the biological and physiographic diversity of a natural region. This is the number of characteristic features present in a protected area relative to what occurs in the region. It also has spatial attributes in considering the proportion and occurrence pattern of these features (Mondor 1997). In order to ensure that special elements and phenomena such as hotspots of endemism, important migratory stopovers, critical breeding areas, as well as geological and soil landscape features are captured by the representational approach, multiple geographic scales are to be considered (Poiani and Richter 1999).

The conservation targets for ecological representation are based on a landscape analysis of the Manitoba lowlands natural region and consist of the following:

1. Objective: Protect regional and coarse-scale diversity of aquatic and terrestrial ecosystems and features. Elements: Diversity of aquatic communities (lakes, wetlands, shorelines); diversity of plant communities (boreal coniferous forest, mixedwood forest, grasslands, deciduous forest); diversity of physical features (ancient beaches and shorelines, limestone karst, calcareous shales). Conservation targets to be representative of the natural region for each element.
2. Objective: Protect important local-scale aquatic and terrestrial patches and site-specific features. Elements: Spawning and nursery areas; artesian springs and tufa mounds; eastern white cedar; endangered, rare, and threatened species and sites. Conservation targets to be included for each of the elements.

Results of the landscape analysis indicate that the proposed Long Point 96 boundaries do not adequately capture the regional representation of plant communities: mixedwood and deciduous forests are represented, but only account for 8% (10,560 ha) of the area (compared with 24% in the natural region as a whole) and occur in patch sizes of less than 400 ha (Figure 51.3). The original 17% prairie grass cover of the natural region is not represented, and it will be impossible to adequately do so in this proposed national park due to land-use changes (i.e., conversion to agriculture) and the proposed park's location, which lies northward of the mixed prairie zone. The boundaries also fail to capture the representation of lake sizes: the number of medium-sized lakes (100-1,000 ha) is under-represented, with only two such lakes included, covering 3% of the total area of the proposed park.

At the local scale, the Long Point 96 boundaries encompass two ecological reserves and sites of threatened and endangered plant species (COSEWIC 2000) but fail to include some areas of local importance, such as caves, artesian springs, and tufa mounds.

To increase representation of aquatic and terrestrial ecosystems, the CTA should include a large area to the southwest of the proposed boundaries (Figure 51.3). This will increase representation of the mixedwood and deciduous forests and the medium-sized lakes. Moreover, local features and rarer plant communities, such as willow shrub stands and marshes, would be better protected.

- ***Ecological objective 2:*** Maintain ecological processes and characteristic rates of change that support the continued viability of species intact.

The proposed national park's mandate is to ensure that ecological systems and their supporting ecological processes, such as disturbance regimes, are maintained within their natural range of variability over the long term. Fire is the most important factor shaping the boreal forest of the Manitoba lowlands. Unfragmented landscape, or "wilderness areas," have also been recognized as reservoirs of biodiversity and evolving ecosystems. Wilderness areas are parts of the landscape that are unfragmented and distant from human access; an area is considered to be fragmented when it is divided into smaller patches resulting in metrics that differ from those of the natural landscape (Wilcove et al. 1986; Kattan et al. 1994). Such changes in the landscape, linked to habitat loss and increased human access, are usually unfavorable to the reproduction and survival of animal species showing specialization to the original habitat or landscape. Moreover, populations occupying the smaller patches or fragments are often confronted with a multitude of factors impinging on their survival (Andrén 1994; Meffe and Carroll 1994; Collinger 1996).

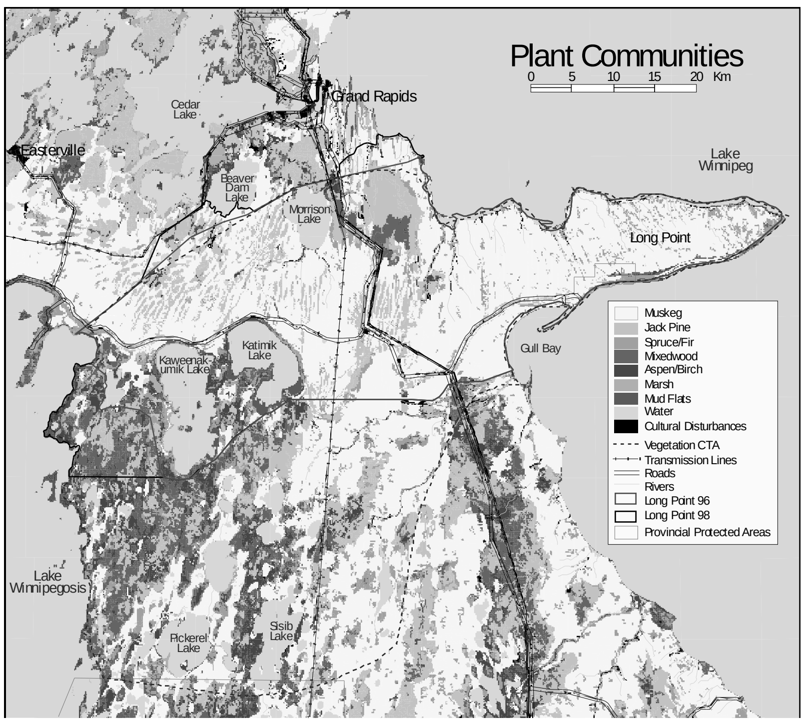

Figure 51.3. Plant communities of the Long Point component.

The conservation targets for ecological integrity, based on a landscape analysis of the natural region, consist of the following:

1. Objective: Protect the ecological integrity of the aquatic and terrestrial ecosystems. Elements: Connectivity between water bodies; include a wilderness area—a landscape that is unfragmented and distant from human access. Conservation targets to be included for each of the elements.
2. Objective: Ensure park size is sufficient to support the region's forest fire disturbance regime. Elements: Include a large wilderness area; natural topography, such as lake and river drainage systems; and a diversity of vegetation. Conservation targets to be included for each of the elements.

The proposed Long Point 96 boundaries do not capture entire watersheds; they also sever seven rivers and creeks and embrace the lake shorelines on just four occasions (Figure 51.4). The proposed boundaries do not secure the protection of spawning and rearing grounds and, on the north, overlap with the Manitoba Hydro water power storage reserve, an area subjected to continual water-level fluctuations. Moreover, the Long Point 96 boundaries include a large number of linear disturbances, including Highways 6 and 16, two hydropower transmission corridors, and a number of winter roads and trails resulting in a road density of 0.24 km/sq km.

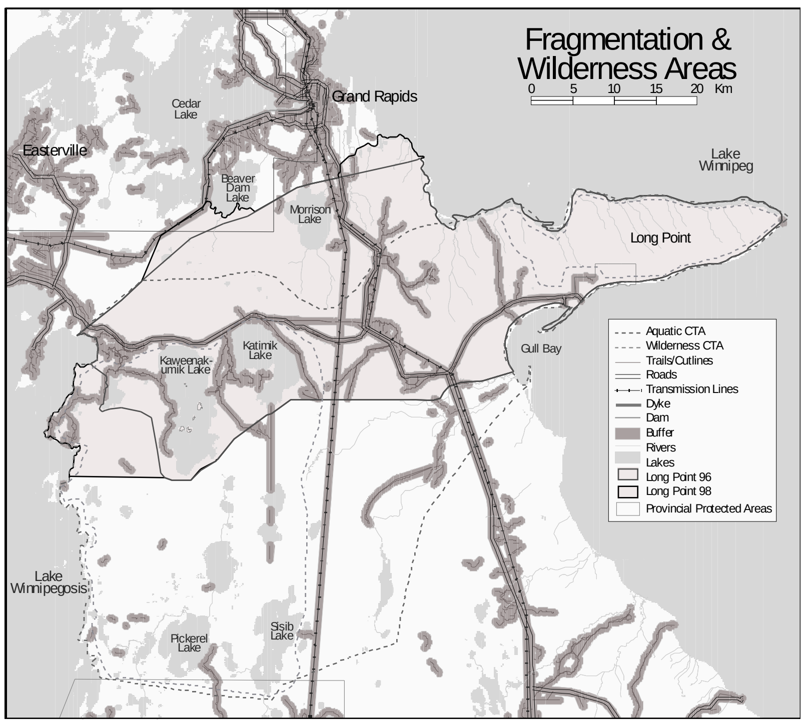

Figure 51.4. Fragmentation and core wilderness area of the Long Point component.

In order to maintain the ecological processes and characteristic rates of change that support the viability of plant and animal species, the proposed CTA includes an area to the south to ensure that waterways are not severed, that lake shorelines include a buffer area, and that a core unfragmented area is included (Figure 51.3). Moreover, this additional area captures a complex pattern of small- to medium-sized lakes with good connectivity, wetlands, and shorelines of great ecological value. The proposed CTA also excludes an area to the northeast to be more distant from the water power storage reserve and the core of Manitoba Hydro activity. The largest unfragmented patch would be twice as large in the CTA (106,930 ha) as that found in Long Point 96 (51,430 ha) and would provide connectivity with another protected area.

- ***Ecological objective 3.*** Encompass habitat requirements of viable populations of the region's native species, in natural patterns of composition and abundance to the extent possible.

An environment presenting different biotic and structural characteristics offers food and cover for a number of animal species. Some habitats are more productive than others, and are often referred to as "sources." In source habitat, individuals are produced in excess and are led to emigrate to less-productive habitats. These source habitats depend on the species' requirements and other life-history traits. A good representation of these habitats, along with adequate connectivity between suitable patches, is of great importance and is likely to have a significant effect on population numbers (Andrén 1994; Fahrig 1997; Bender et al. 1998).

The conservation targets for viable animal populations consist of the following:

1. Objective: Meet habitat requirements of regional- and coarse-scale aquatic and terrestrial species. Elements: Woodland caribou, wolves, elk, and moose; spawning and nursery areas. Conservation targets to be included for each of the elements.
2. Objective: Meet habitat requirements of local-scale aquatic and terrestrial species. Elements: Staging and breeding grounds for shorebirds, waterfowl, and raptors; habitat for endangered, rare, and threatened species. Conservation targets to be included for each of the elements.
3. Objective: Ensure connectivity between different part of a species' range, between populations and metapopulations. Elements: Corridors to allow species movement between different parts of their range. Conservation targets to be included for each of the elements.

The Long Point 96 component contains source habitat for woodland caribou: lichen-rich boreal habitat consisting of predominately jack pine uplands interspersed with black spruce and tamarack bogs. The 19,920 ha of jack pine uplands are, however, only a fraction of the average home range for woodland caribou (Figure 51.3) and is highly fragmented with more than 24% of the area in roads, trails, or hydropower transmission lines. To help with the protection of this threatened species, it is important to include large unfragmented areas, good winter habitat, and corridors to the north to provide some connectivity with other populations. However, the fragmentation to the north is noteworthy with a large hydropower reservoir, transmission corridor, forestry activities, roads, trails, and townsites.

As another example, the proposed boundaries also contain some high-quality habitat for elk—upland mixedwood forest mainly occurring southwest of the Long Point area (Figure 51.3). Again, the 8,116 ha of mixedwood and deciduous forests only account for a fraction of the species' range; to maintain a viable population of elk, additional range with some connectivity to the Chitek Lake reserve and the remaining part of the species' range is paramount.

The current boundaries of the Long Point 96 component protect important breeding-bird colonies and staging grounds for a large number of shorebirds and waterfowls.

An additional area to the south–southwest of the Long Point 96 area would allow for more unfragmented land, some connectivity with another protected area, and the protection of local sites of importance. The proposed park area remains highly fragmented, however, with more than 16% of the overall area, or 39,948 ha, under some form of linear disturbances. Regional management will be necessary for the long-term protection of the large mammal species.

Boundary or boundaries?

The outcome of the analysis identifies an area south of the proposed Long Point boundaries that is of ecological importance for its terrestrial and aquatic diversity, the integrity of the waterways, and its distance from human disturbance (Figure 51.5). The second significant result of the analysis underlines the necessity to think beyond park boundaries—already at that stage—to maintain some connectivity to the south and to the north for the viability of long-ranging animal species such as caribou, elk, and wolf. This can be achieved through the extension of the park boundaries and other shared-management options.

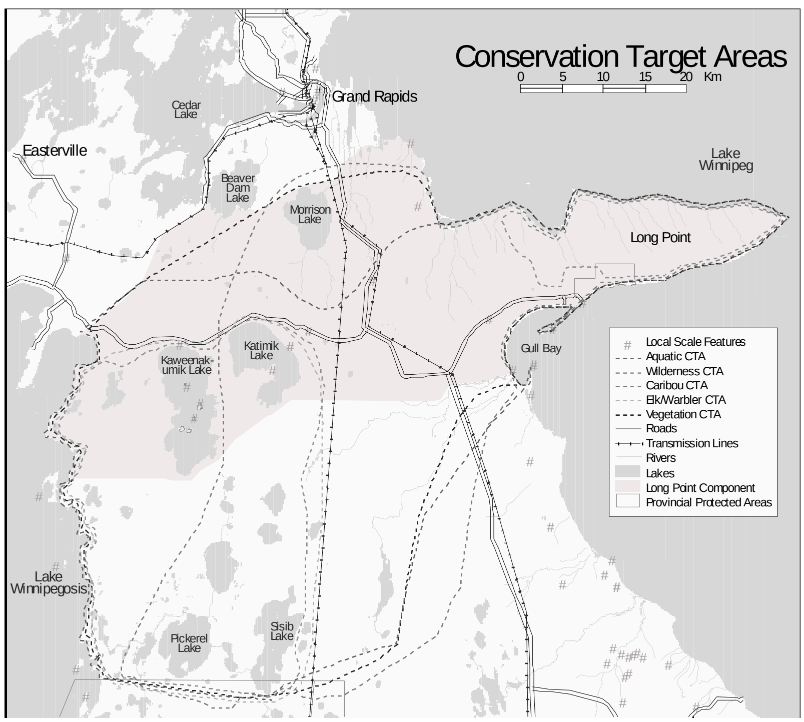

Figure 51.5. Conservation target areas for the Long Point component.

To support negotiations over the status of this land, we opted for a number of boundaries instead of one line on a map for the following reasons:

To ensure the openness of the process and better involve the different stakeholders in the reflection. A number of ecological indicators have been used to portray the Interlake ecosystems, and additional ecological and cultural features will be added as they are identified. People of the Interlake area have an intimate understanding of their homeland and, as the reflection continues, ideas will be shared and built upon, new lines will be drawn and re-drawn, until we have a common vision of the system.

To better contribute to the decision-making process. It is in the power of science to provide information to decision-makers. The multi-boundaries approach, in providing an understanding of the different ecological processes occurring at different landscape scales, should encourage people to come together to examine and discuss conservation options. In the spirit of ultimately sustaining wildlands and wildlife as well as communities and regional economies, ecological information on these complex landscapes is being conveyed and shared.

Are we going to have ecological boundaries? Forestry and hydropower industries have significant interest in the area, particularly that portion lying to the south–southwest of Long Point. The area is licensed to a forest company and the province is challenged to find compensation (additional wood fiber) for the area. Moreover, Manitoba Hydro's northern generation planning foresees an additional high-voltage transmission corridor through the area. Faced with an already high level of fragmentation, additional access and activities in the area are possible only if carefully planned and mitigated. Conservation of our natural ecosystems can succeed only if there is a concerted effort among stakeholders to develop long-range, integrated conservation and regional plans.

Acknowledgments

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52 The Algonquin to Adirondack Conservation Initiative: a key macro-landscape linkage in eastern North America

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Introduction

Viable regional—and, ultimately, continental-scale—protected area networks are clearly a prerequisite for successful biodiversity conservation. This hierarchy of core areas, linkages, and compatible surrounding lands is exemplified at the continental scale by the Wildlands Project (Noss 1993; Wild Earth 2000) and its flagship, the Yellowstone to Yukon initiative. Associated regional-scale network visions and proposals are being developed elsewhere in North America. The Great Lakes region is spatially complex and conservation initiatives are constrained by intense human use, but a regional protected area network here is an essential component of any continental-scale vision. The requirement that these protected area networks must be planned and that each component be part of an integrated design across scales is critical. These ideas are implicit in the modern protected area paradigm (Stephenson 1995).

It is also reasonably well accepted in conservation circles that ecosystem management in the broad sense, involving fairly radical shifts in human values and economics as well as changes in our approaches to land use and resources allocation, is a prerequisite for a more sustainable society in the future (Noss 1994; Costanza 1997; Agee and Johnson 1988).

Two contributing but complex concepts are important to understand. The first is the role of spatial visioning in conservation planning. The idea is not new; zoning and transportation plans are spatial visions based on mapped planimetric data. The availability of satellite and other forms of visual information, combined with the capabilities of geographic information systems (GIS) technology, have made spatial visions currently popular (Table 52.1) with scientists, land use decision-makers, and the public (Groves et al. 1998; Jalava et al. 2001).

The second concept is the science underlying the use of cores and corridors (the main elements of spatial visions), which is uncertain and has received some criticism. Certainly the differences between viable cores and "sinks" need to be appreciated. Likewise, the distinction between corridors for the movement of individuals between populations and those that act as actual habitat linking larger habitat cores needs to be understood (Hudson 1991; Soulé and Terborgh 1999; Merriam 2001). Scale is the key. Large cores (and compatible surrounding uses), especially if they were planned to conserve umbrella or keystone species, are clearly more likely to be viable in the sense of conserving all aspects of biodiversity than small ones. Further, at the smaller scales where the movements of individuals are involved, it is often the current, not the potential, landscape that has been evaluated (Fahrig and Merriam 1994; Beier and Noss 1998). Suitable corridors for most species are not likely to be found in existing remnants, so design and restoration are required.

The larger the scale, the less these concerns pertain and the more patterns of mountain, valleys, and rivers that generate "functions" become relevant. This paper is focused on what I call the "macro-landscape" scale, comparable with what is now

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often referred to as “bioregional land use planning” (McNeely 1999; Szaro 1999; Miller and Hamilton 2000).

- Responds to advances in science, such as landscape ecology and conservation biology;
- Can take advantage of existing or anticipated land use opportunities, such as abandonment of agricultural land or projected development patterns near urban areas;
- Is easily revisable using GIS so many alternatives can be investigated;
- Incorporates a range of approaches—especially restoration, which is important wherever humans have exploited the land;
- Makes it easier to involve individuals and organizations interested in all forms of private stewardship as well as governments; and
- Provides a “picture” that is worth far more than a thousand words of explanation.

Table 52.1. Benefits of spatial visioning.

The Great Lakes

The Great Lakes is a global-level biome. Most people can call up in their minds the general shape of the five lakes drained by the St. Lawrence River and its south-west-to-north-east orientation (Figure 52.1). Fewer appreciate that these lakes penetrate fully one-third of the way across North America, creating a substantial barrier to north–south plant and animal movement, with the exception of those that disperse aerially. The potential habitat changes and relatively short time frames implied by human-induced change make this barrier of greater concern today than in the past.

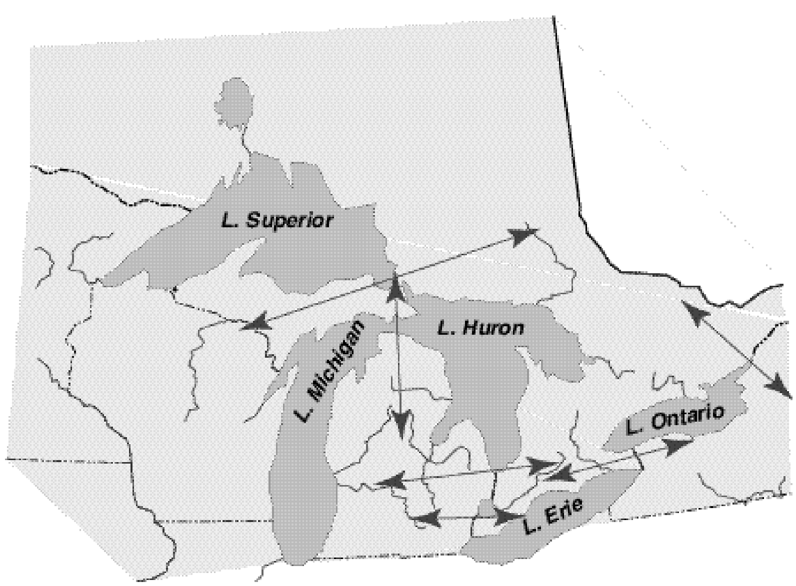

Figure 52.1. “Land” crossing points, Great Lakes Basin.

Figure 52.1 also shows the major land-based migration routes across the Great Lakes. All have been compromised, but all have potential for a continued biogeographical role, particularly through the use of protected areas and conservation designations. Ensuring this dispersal capability will become more important in a future that features global climate change and the subsequent shifting of species ranges and large-scale migrations in response. From west to east we can see:

- Lake Superior macro-landscape corridors reaching north from Nipigon Bay up the Nipigon River to Nipigon Lake, Wabakeimie Provincial Park, and, ultimately, to the Hudson Bay watershed. Additional corridors fan out to the east, linking at Sault Ste. Marie, and to the west across the proposed Lake Superior National Marine Conservation Area, Sibley Provincial Park, and Isle Royale National Park, and more southerly to Apostle Islands National Lakeshore and then towards the upper Mississippi River watershed.
- At the junction of Lakes Huron, Michigan, and Superior several corridors intersect. Movement is possible from the state of Michigan to the north along a Lake Superior shore dotted with small protected areas. The Lake Superior shore is now connected to the Georgian Bay shore through the heritage coast concept that arose from the Ontario Lands for Life (OMNR 1999) process. A route can also be envisioned from southern Georgian Bay to the Ottawa River. Importantly, the "Niagara Escarpment" also extends west through this junction into the Upper Peninsula of Michigan with extensive state and national forests, and along the west side of Lake Michigan. To the east, the escarpment includes Manitoulin Island and the Bruce Peninsula as it winds through south and central parts of Ontario across the gap between Lakes Erie and Ontario to the Finger Lakes region of New York (Nelson 2001).
- In the southern Great lakes a series of smaller corridors exist. One is at Lake St. Clair, three cross Lake Erie from the national and provincial parks at Point Pelee, Rondeau, and Long Point on the north shore, and another connects Prince Edward County to the south across Lake Ontario. The last corridor is across the St. Lawrence River in the Thousand Islands area using the Frontenac Axis to link Ontario's Algonquin Provincial Park to Adirondack State Park in New York.

If one views these corridors from a "glass half empty" perspective, most are compromised. The Sault Ste. Marie junction is very constricted and developed. The junctions near Lake St. Clair and Niagara are certainly alienated. Some, such as those in Lake Superior, involve great expanses of water, creating an even more "stepping stone" approach than a completely terrestrial corridor. Others, such as those crossing the southern Great Lakes, do not appear to link to even valid stepping stones, although bioregional restoration and connectivity planning is occurring in southern Ontario through the work of the Carolinian Canada Coalition (http://www.carolinian.org).

If our "glass is half full," the now-inadequate connectivity along these routes can be supplemented and their capacity to facilitate biotic movement and large ecological functions enhanced. It is evident that the best of these macro-landscape linkages (in the sense of current potential) is that across the St. Lawrence River. A more detailed examination of this location illustrates how spatial visions for all these routes can be further conceptualized.

Eastern Ontario and northern New York

The Frontenac Axis, a bedrock formation that creates the Thousand Islands stretch of the St. Lawrence River linking the Canadian Shield to the Adirondack Dome, is central to a spatial vision for this region. Figure 52.2 provides a graphic illustration of the macro-landscape linkages and conservation potential spreading out from the Thousand Islands nexus.

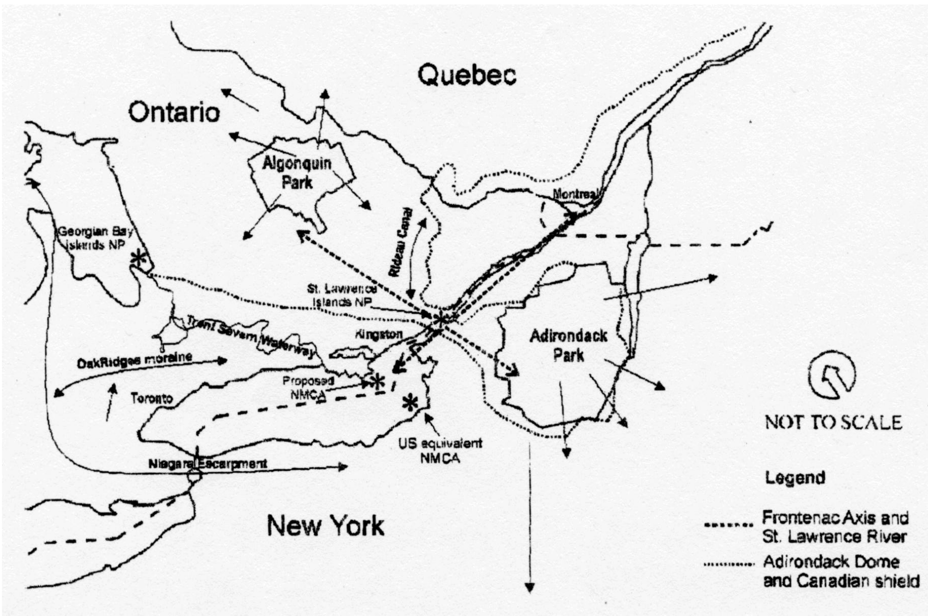

Figure 52.2. Landscape framework concept for central and eastern Ontario.

Macro-landscape ecosystem functions are rarely recognizable in patterns of protected areas established for various purposes by the many jurisdictions involved at this scale. Further, protected areas are usually physically and institutionally isolated from their surroundings. In the case of the Thousand Islands nexus, the protected area pattern does to a certain extent reflect the macro-landscape ecosystem functions.

The St. Lawrence River is edged by park lands (under the jurisdiction of the St. Lawrence Parks Commission and its U.S. equivalent) with a concentration of New York state parks (e.g., Wellesley Island) and a Canadian national park (St. Lawrence Islands) at the nexus itself. Near the start of the St. Lawrence River in northeastern Lake Ontario, Parks Canada has identified the possibility of a national marine conservation area in the lake. Adjacent to it are Parks Canada lands at Prince Edward Point and Department of National Defence properties on the lake side of Prince Edward County, which also has several provincial parks, such as Presqu'île and Sandbanks. A national marine conservation area here could be complemented through a Canadian request for consideration of an appropriate designation in the USA portion of Lake Ontario.

The Frontenac Axis likewise has existing protected areas. such as Charleston Lake and Bon Echo provincial parks, as well as extensive public lands as it widens north from the St. Lawrence River. Significantly, the Frontenac Axis is anchored by two of the largest protected areas in eastern North America: Algonquin Provincial Park and Adirondack State Park. They create core protected areas at either end of what is essentially a terrestrial movement corridor. The sets of rivers for which these two parks are headwaters also include a variety of protected areas as they spread out from the cores.

Further from the nexus along the edges of the Canadian Shield to the northeast and northwest, two federal conservation corridors along the interface of the shield and the St. Lawrence Lowlands, the Rideau Canal and the Trent-Severn Waterway, already exist. Peripheral to Algonquin Provincial Park and Adirondack State Park are extended protected area opportunities in the form of the Madawaska Highlands in Canada and the Lake Champlain Biosphere Reserve, which in fact links to the Great Northern Forest of Vermont and Maine. To the west, the Oak Ridges Moraine and the Niagara Escarpment figure prominently. Of course, to the north in Ontario the Canadian Shield stretches for hundreds of kilometers, while to the south in New York state the Appalachian Mountains form the eastern spine of North America.

The Algonquin to Adirondack Conservation Initiative

Spatial visions are a fine essential tool for large-scale conservation planning, but they remain paper fantasies until they engage the public, especially decision-makers, and have been translated into on-the-ground actions. The key to realizing the macro-landscape conservation potential of eastern Ontario and northern New York is the corridor across the Thousand Islands. A multi-partner coalition, the Algonquin to Adirondack (A-to-A) Conservation Initiative, is already in place and is gradually establishing the need and catalyzing the actions of residents and local governments.

The entire corridor between the Algonquin and Adirondack parks is about 270 km long, but the critical Frontenac Axis portion is 100 km long and 60 km wide. Except in the St. Lawrence River Valley itself, the terrain is rugged with exposed bedrock and thin soils. Much of the land is relatively unaltered since the first lumber harvest swept across the region. Although governments of that era promoted farm settlements, the poor agricultural capabilities have led to abandonment of fields and considerable natural recovery. As a result, human population density is low and there are few towns (except along the St. Lawrence River) near which roads and utility rights of way are also found. Not surprisingly, private land ownership is greater near the river, but considerable public lands are found farther from it.

The Thousand Islands and adjacent areas of New York (e.g., Lake Placid) attracted summer visitors from large eastern seaboard cities, and many industrialists established extensive retreats in the mid-to-late 1800s. Since then the entire region has evolved into an internationally recognized tourist area famous for the beauty of its natural landscapes. As shown previously, numerous protected areas have been established and much of the private lands support outdoor recreation complemented by water sports and fishing on the St. Lawrence River and at the eastern end of Lake Ontario. Generally, the permanent residents appreciate their environment, are not in conflict with seasonal residents or tourists, and have established a strong, positive cross-border relationship. Active interest in conservation is evident, for example in the Adirondack Park Council and the presence of land trust organizations in Canada and the USA.

This combination of circumstances means A-to-A is not fraught with crisis-level urgency or demands for large new protected areas, as is often seen elsewhere in North America. Continued recovery through education and consensus-building that actively leads to a more sustainable natural environment is the operative strategy.

The A-to-A mission is "to restore, enhance and maintain ecological connectivity, ecosystem function and native biodiversity, while respecting sustainable human land uses in the distinctive region of Ontario and New York State that lies between and embraces Algonquin and Adirondack Parks." Table 52.2 lists the operating principles used. The premise is that the connection will best be maintained, not by government policy or imposed regulations, but by the voluntary actions of thousands of individual landowners. Their new vision of landscape conservation will be based on the shared belief that the cumulative effect of thousands of individual actions will keep this link alive throughout this century and into the future (CPAWS 1999).

Creating effective organizations to deliver conservation is usually a demanding task. The "converted" are often already over-committed; convincing others is a delicate first step, and champions with the time, energy, and knowledge to lead are few and far between. These factors have affected A-to-A. In addition, the international aspect has created barriers, even between two very similar friendly countries with strong local relationships. Differences in how charitable organizations incorporate and how land trusts operate, different local and municipal planning procedures, and, in some circles, an unreasonable concern about "foreigners" have come into play.

- ***Stewardship.*** Stewardship is caring for the land, and making choices about how to manage a property so as to maintain the land's desired characteristics;
- ***Cooperation.*** Scientists and landowners must work together to combine conservation biology with the needs of the people living on the land;
- ***Not bounded.*** Maintaining ecological integrity throughout the Algonquin to Adirondacks region requires that people transcend political boundaries;
- ***Flexibility.*** Partners in the A to A effort must acknowledge that they will have to learn as they go and be flexible in their planning;
- ***Long-term change.*** Achieving sustainable communities while maintaining healthy natural habitat is a long-term process, and achieving the A to A vision will require many incremental changes.

Table 52.2. Six principles that guide the A-to-A.

The result, after some false starts, is a dispersed organization. Major conservation interests, such as the Canadian Parks and Wilderness Society in Canada and the Wildlands Project in the USA, have assumed an "umbrella" role, while regional-scale organizations have been established in both countries.

While progress sometimes seems slow or uneven, all A-to-A participants realize that the conservation initiative is long-term. There is no immediate need to deflect continued rural development or establish significant new protected areas in order to be successful. Confrontational issues can be identified and worked through systematically. This type of protection campaign is different than the crisis situations most familiar to conservation activists. New styles of working are being learned and the tangible accomplishments are mounting (Table 51.3). Obviously far more information is available on the A to A Conservation Initiative and more will come on stream as momentum grows. A good starting point for the curious is the Web site http://www.AtoA.org.

Conclusion

The idea of large-scale conservation planning presented here is not unique globally or for the Great Lakes. In fact, it is the amount of large-scale planning on the Great Lakes (e.g., Harkness et al. 1999; Zorn and Quirouette 2000; Lake Erie LAMP Working Group 2000) that creates the potential for a protected areas network vision that contributes to a healthy biome with sustainable human activities.

The factor that characterizes all these planning activities is that they are for limited areas or address specific issues in the Great Lakes basin. None begin with a large-scale concept of sustainable land use and resource allocation featuring a protected areas system in a ecologically healthy land use mosaic. In every case, however, the ideas espoused are at scales greater than traditional land use planning for municipalities, counties, or small watersheds. Land use planning is similar to putting a jigsaw puzzle together. Single pieces or groups of pieces sometimes make sense and seem independent, but the "big picture" is not clear until the pieces are integrated. Most people wouldn't start a 1,000-piece jigsaw puzzle without studying the picture on the box as a guide to the direction needed and the eventual results. We seem ready to ignore these bigger pictures when it comes to making decisions about the world we depend on, however.

· Initial feasibility study (Keddy 1995)
· Frontenac Axis Research Needs Symposium (1995)
· Algonquin to Adirondack Interdisciplinary Research Workshop (2000)
· Brochure and slide show
· Presentation to community groups and local governments
· Canadian Steering Committee
· St. Lawrence Region "chapter"
· Three broad-based organizing workshops (1996, 1997, 1999)
· Mission, vision, principles
· Available GIS data (zoning, land use, ownership, natural)
· Wolf habitat suitability analyses, Canada and USA (Quimby et al. 2000; Trombulak and Lane 1999)
· Successful funding contacts
· Ongoing full- or part-time paid staff
· Numerous media articles
· Recognition by national conservation interests
· Algonquin to Adirondack International Trail study (Beaubiah 1999)

Table 52.3. A-to-A accomplishments, completed or ongoing.

Parks Canada in Ontario (along with many others) recognizes these facts and wishes to encourage a cooperative, basinwide vision that can guide as well as provide a general template to measure success. This vision can focus effort and funding to those aspects of land use most critical to the future. Parks Canada will continue to advocate the need for such a consensus-based vision for the Great Lakes and help to catalyze it as part of its work on greater park ecosystems for Ontario national parks.

The take-home message of this paper, then, is that all the interacting agencies and individuals living in the Great Lakes basin need to work together for a secure, healthy future.

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53 More than a database: the National Park Service's Cultural Landscapes Inventory improves resource stewardship

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The Cultural Landscapes Inventory (CLI) is a comprehensive inventory of all historically significant landscapes within the National Park System. An overview of the CLI is included here, followed by specific case studies describing how CLI information is being used to assist in park management.

The CLI is an evaluated inventory that provides baseline documentation for cultural landscapes. It documents general descriptive information, existing documentation, and management information. The CLI looks at the physical development and historical significance of the landscape, including eligibility for the National Register of Historic Places. Existing and historic characteristics that contribute to the significance are described and evaluated. They include characteristics such as natural systems, spatial organization, land use, vegetation, circulation, structures, and views. The CLI also assesses the integrity and condition of the landscape. Information is gathered primarily from secondary sources and through field surveys of the landscape. To automate the inventory, the Cultural Landscapes Automated Inventory Management System (CLAIMS) database was created in 1996.

A hierarchy was developed to accommodate the diversity of cultural landscapes. A large landscape may be broken into component landscapes, which allows each to be documented in more detail. The hierarchy also allows for the documentation of features that contribute to a site's historic character, such as a building, fence, or planting.

There are four types of cultural landscapes. *Historic designed landscapes* range from the National Mall in Washington, D.C., to small designed gardens. The second type is *vernacular landscapes*, including villages and farms (Figure 53.1). The third type is *historic sites*—those places associated with important people and events, such as the homes of presidents or battlefields (Figure 53.2). And the last type is *ethnographic landscapes*, those sites associated with traditional cultures, which include both ancient Indian sites and places where cultural traditions continue today.

The CLI is completed in a four-level process, with each level building on the previous one. They are:

- Level 0: The *park reconnaissance survey* identifies the scope of landscapes and component landscapes in a particular park, existing and needed information about the resources, and immediate threats to the resources, and establishes priorities for Level I inventory.
- Level I: The *landscape reconnaissance survey* identifies existing and needed information for a specific landscape or component landscape in a park and estab-

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lishes priorities for Level II inventory. A site visit is conducted and an initial evaluation is done of the significance and character of the landscape or component landscape.

- Level II: The *landscape analysis and evaluation* defines the landscape characteristics and their associated features of a specific landscape or component landscape. Both existing and historic conditions are analyzed to determine contributing character-defining features. National Register eligibility is evaluated and integrity and condition assessed. Landscapes at this level are on, or eligible for, the National Register, or are otherwise treated as cultural resources.
- Level III: The *feature inventory and assessment* provides an inventory and evaluation of a physical feature identified in Level II as contributing to the significance of a landscape or component landscape.

Thus, the CLI is an ambitious undertaking that provides many benefits. The next section focuses on examples from specific parks and illustrates how the CLI is assisting in resource stewardship.

Figure 53.1. Edisen Fishery at Isle Royale National Park is an example of a vernacular landscape. Photo by NPS Midwest Regional Office CLI, 1997.

Big South Fork National River and Recreation Area

Big South Fork National River and Recreation Area encompasses approximately 123,000 acres on the Cumberland Plateau in northeast Tennessee and southeast Kentucky. The Cumberland Plateau is characterized by two very distinct landscapes: the plateau itself, with gently rolling, forested hills; and the gorges that run through it, made by the action of rivers such as the Big South Fork of the Cumberland River.

Starting with Native Americans, the region has been considered valuable for its natural resources. Both the Cherokee of the Tennessee Valley and the Shawnee of the Ohio Valley claimed the Big South Fork region as a hunting ground. By the mid-1700s, European Americans had begun to explore the area. Between the Revolutionary and Civil wars, the first major influx of settlers came to the Big South Fork, establishing farmsteads on the relatively fertile land in the gorge. These subsistence farmers supplemented their income with small-scale niter mining, salt extraction, and oil drilling. Farming was following by an increase in the extractive industries, including oil, coal, and timber. By the mid-20th century, much of the land had been cleared of timber and polluted by oil drilling and coal mining. Plans to dam the gorge were made in the 1930s and again in the 1960s, but public opposition kept the designs from being implemented. In 1974, Big South Fork National River and Recreation Area was authorized, and in the following years land within its legislative boundary was purchased, ranging from tracts of former logging land numbering in the thousands of acres to small family parcels. In 1976, the U.S. Army Corps of Engineers named the National Park Service (NPS) the interim manager of the park, and in 1990 lands and management were fully turned over from the Corps to NPS.

Figure 53.2. Bloody Lane at Antietam National Battlefield is an example of a historic site. Photo by Nancy Brown, 2000.

Beginning in 1997, the cultural landscape team from the NPS Southeast Regional Office in Atlanta, Georgia, began documenting the many cultural landscape features of the park for the CLI Level I. Features at the park included cemeteries that were both actively tended and long ago abandoned. Industrial remnants at the park included an intake valve at the Blue Heron Mine site and the Beatty Oil Well. Transportation features, like a stone-lined footbridge at No Business Creek, remained in place, as did evidence of subsistence farming, in the form of remnant fields, farmhouses, and fences.

Using ArcView geographic information systems (GIS) software, the cultural landscape team mapped these cultural resources and produced a large-scale drawing showing all the different features. The next step was to synthesize this information and generate a cultural landscape hierarchy. Some features were very remote and were the only remaining part of a formerly intact cultural landscape. However, several farmsteads were found to retain enough integrity to warrant listing on the National Register. More attention was focused on these farmsteads, which were now regarded as component landscapes within an overall Big South Fork landscape. For each of the component landscapes a more detailed inventory was conducted. They were also mapped at a closer level of detail using AutoCAD.

This baseline inventory has become a valuable source of information for the park and for the region. Natural resources have been mapped using GIS, including ArcView, for many years. Beginning to map cultural resources in the same format prompts a better dialogue between these two resource types. The CLI has also been referenced in the ongoing process to develop the park's general management plan. Furthermore, the inventory has been used as the starting point for a National Register multiple-property nomination encompassing all the identified component landscapes.

Schoodic Peninsula, Acadia National Park

For the past two years, Schoodic Peninsula has been the focus of research, fieldwork, and long-term planning by a multidisciplinary group of resource professionals. This serendipitous timing of work was prompted in part by the U.S. Navy, which is decommissioning a cryptography base on the peninsula with the intent to transfer the property to Acadia National Park. Now the challenge remains to re-use, interpret, and protect the base and the surrounding peninsula with its island-studded views, deep woods, and complex history.

With assistance from the Navy and local residents, several NPS projects were initiated that will provide crucial information about the cultural resources on park lands at Schoodic. These ongoing projects include a nomination to the National Register for the Schoodic Peninsula Historic District and two CLIs. The information compiled for these projects will also be used in preparing an amendment to the park's general management plan.

The major challenge was to describe and evaluate extant cultural landscape features on Schoodic Peninsula for multiple projects. To accomplish this, a three-phase data collection strategy was implemented. The first phase consisted of collecting copies of historic documents through archival research. Pre-existing studies completed by NPS, the Navy, and the University of Maine were also consulted. The next phase consisted of inventorying and evaluating cultural landscape features in the field. At the conclusion of the fieldwork, a checklist was produced to guide the global positioning systems (GPS) mapping, the last phase of the project. Under the direction of Nigel Shaw, GIS program manager of the NPS Northeast Region, a GPS "swat" team was assembled to collect the data in the field. Members of the team split into pairs to complete the data collection process.

The GPS team collected georeferenced data on the vast majority of the cultural resources on the peninsula within park boundaries. These included the visitor facilities and park support facilities, such as buildings, structures, small-scale objects, parking areas, signs, and roads. Small-scale engineering features, such as culverts, headwalls, and steps, were also mapped. Landscape features, such as historic orchard remnants and vegetation boundaries, were also included. Additionally, some of the known archaeological sites were mapped, as well as the park's northern boundary.

At the conclusion of the fieldwork, the GPS data were compiled and edited at the New England Technical Support Center, University of Rhode Island. The data layers will be superimposed on digital orthophotographic quadrangles supplied by the Navy. Maps will be generated to accompany the CLIs and the National Register nomination. Most importantly, the GIS data will assist Acadia's staff in resource management, planning, interpretation, and maintenance efforts.

The concurrent nature of these cultural resource projects at Schoodic presented a fortuitous timing of work. Specifically, it provided an opportunity to integrate archival research and fieldwork efforts, as well as the collection of georeferenced data using GPS and GIS mapping strategies. Ongoing archaeological surveys at Schoodic also contributed to a greater understanding of the early history of the peninsula. The existence of recently completed biological, geological, and palynological studies provided an excellent opportunity to synthesize existing studies and to view the peninsula through the lens of environmental history. The one-time, intensive-mapping phase by a GPS swat team resulted in greater efficiency of data collection, as well as more uniform results. Individual members of the team not only learned or perfected their GPS skills, they also had the rare opportunity to work together and share their expertise.

Conclusion

The CLI is a relatively new program, but has already added to the knowledge and understanding of park landscapes. It is providing valuable information that assists in protection of resources, and is used for park planning and maintenance decisions. The information enhances the story being told in many parks, adding to the overall visitor experience. The CLI is improving stewardship of the landscape resources significant to this nation's heritage.

54 Managing data to bridge boundaries

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I want to start with an example of the complex situation we face in managing data today in the National Park Service (NPS). Consider a small plot of vegetation adjacent to a park trail. A plot containing species of concern—they could be frequently poached cacti, threatened or endangered species, an exotic plant invasion, a plant endemic to the park, or a plant of ethnological concern. The plot of ground in question is of interest to a broad range of audiences, within and outside NPS. Let us consider where data relevant to this plot might be kept.

First, let us assume that, through an inventory, the plant's location is loaded into the park's geographical information system (GIS). Since we are assuming this park has a GIS, it is safe to assume that the trail is plotted there, too. Information about the plant is also stored in the National Park Service's species database, NPSpecies. Along with identifying that the plant is present in the park, various quantitative and qualitative data and metadata are stored—such as the coordinates where the plant was found, the location of the voucher specimen and its catalog number, and information on any publications about the plant in the park. Being in NPSpecies, these data could easily be shared with the Association for Biodiversity Information (formerly in The Nature Conservancy), the U.S. Geological Survey Biological Resources Division, and others. When the database is more fully populated, it will be available on the Internet, except for certain fields, which will be protected. The voucher specimen for the plant is not only described in NPSpecies, but is also in the Automated National Catalog System, the NPS catalogue for all types of collections.

Trails are facilities, and the location and length of the trail will also be stored in the Maximo facility database, as will (one would hope) information about its condition, including the condition of the soils, such as whether erosion is occurring, and the condition of vegetation adjacent to the trail. Finally, Maximo will be used to plan and schedule work to be done on the trail, including, perhaps, pertinent information about revegetation prescriptions.

The presence of species of concern means that the species' presence creates a workload beyond a generic vegetation management workload. As such, the plant's presence in the park, and perhaps other data about it, are captured in the natural resource assessment program park profile for analyzing resource management workloads. So is the fact that there is a trail and information on the miles of trail.

Because both the plants and the trail are of specific management concern, unfunded activities related to them may be included in budget databases, the operations formulation system, and the project management information system, depending on whether the activities are operational or one-time projects. The unfunded needs related to the plants may not have high enough priority to be reflected in an increase request for base funds or a project. Nonetheless, the plant management strategy and any long-term needs should be reflected in the resource management plan and (when completed) its associate database, the resource activity management system. And, if significant enough, in management prescriptions or desired future conditions that are newly required parts of a general management plan.

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If the plant has been vandalized or if another illegal incident or accident took place at this point on the trail, the incident would be captured in the critical incident report system, or will be when a revised automated system is developed. There are other places where data on this plant and this trail may reside. If there are performance goals related to the trail or the plants, information will appear in the performance management data system. Perhaps the trail is historic or has a historic structure incorporated in it; if so, it might appear in the list of classified structures. I am certain I have missed some other important databases. We even have one mega-system in which to link all the databases and flat information with relevance to resources. We call this system "Synthesis."

Driving forces behind recent data management push

Why is information about this small plot stored—or provisions are made to store it—in so many places? Because we are charged as an agency to take care of both the plant resource and the recreational resource. And because this care-taking job is really a series of complex jobs that involves several specialized NPS components. And because we cannot do these jobs without information.

The need for information to do these jobs is becoming more and more widely understood and the magnitude of the need more widely appreciated. A primary basis of NPS's Natural Resource Challenge initiative is the provision of scientifically credible information for informed decision-making. Recently, the House Appropriations Subcommittee on Parks held an oversight hearing on the Challenge. At this hearing, the need for information was taken as a given. Detailed questions were asked about: how we collect information, how we prioritize needs for information, whether superintendents are required to update information, how we avoid duplication, and whether we can roll up and share data across parks with neighboring land managers.

The National Parks Omnibus Management Act of 1998, known familiarly as the Thomas bill, requires NPS to move forward with inventory and monitoring and to document the basis for its decisions. The new Director's Order 12, along with its reference manual, provide guidance on the level and scope of information needed to meet the legal standards set forth in the Omnibus Act, the National Environmental Policy Act, and the Historic Preservation Act, including as they have been interpreted by the courts. Failure to develop and base decisions on adequate information can and has resulted in legal challenges that NPS often has difficulty countering.

National Park Service and other mandates collectively require three things. First, before we take an action with the potential for adverse impact, we must have or develop enough information so that the decision is informed. Second, we must use that information in the decision-making process. Third, we must document how the information is used.

Need for Systemwide approach

The need for park managers to have park-specific data is by now, I would venture, pretty well a given. Most often, the decisions that receive the most public scrutiny entail a specific action in a specific park, such as a road widening or realignment or a visitor management plan that places specific sideboards on how, when, and where certain activities may take place, for example. And park managers will be successful in weathering public scrutiny when their planning and decisions are supported by scientifically viable information. But sometimes we are scrutinized for decisions about programs or policies that affect all parks, such as regulations. We need data about the National Park System to make decisions about the system.

Therefore, one use of data about the system is to support decisions that must pass public and legal scrutiny. Multi-park data also are used routinely to make and support decisions about how to prioritize and deploy limited resources across programs, a region, or the system as a whole—the most obvious of these being budget decisions.

Just as the need for information, and using information, is becoming more and more widely understood, so too is the interconnectedness of parks and the need to act as a system. This interconnectedness and the need to act together apply to fairly routine local decisions and to the very big picture. The public compares each park's management action with those of other parks and views each such action as a precedent for other parks' actions. In this manner, each park's actions affect the management of other parks. The bigger picture, if we are to believe the eminent biologists E.O. Wilson and Peter Raven, is that the National Park System is and will become an increasingly important part of preserving the nation's and the world's biodiversity. For both of these reasons, we can't consider only our own park or other protected area anymore. We must consider the role of "our" park in the National Park System and the role of that system in preserving biodiversity nationally and globally—as well as preserving other nonbiological precious resources that are becoming ever more scarce.

To build on an important admonition, we must do more than think globally about these issues and act locally. To enable local actions to support global approaches to protecting the resources in our care, we sometimes need to act globally, too. This has implications not only for how we manage resources, but also for how we manage information about those resources.

Data need to meet national-level quality standards and need to be accessible to be used for wise and defensible decision-making at all levels. Data need to be able to be shared and aggregated with data from other parks and from adjacent lands to support landscape-level and national planning and decision-making. Indeed, international information standards are important for biodiversity conservation. At the same time, the burden for implementation of standards will rest largely at the park level, with smaller parks perhaps getting help. So it is exceedingly important that park personnel fully understand the utility and importance of resource-related data both to their park and beyond the park, so they can fully own the job they have to carry out. There is a tension here: having information that is useful to parks—which are primarily responsible for its management and upkeep—and at the same time demanding national standards and data-sharing that place requirements on parks that may not have local utility.

Learning from history

The history of the Park Service's attempts to maintain a national-level species database perhaps provide some lessons. In the 1980s, NPS first attempted to be able to talk nationally about what biota were in the parks. The controversy surrounding the publication of William D. Newmark's study on mammal extinctions (Newmark 1987) is illuminating. NPS criticized the study's conclusions about the loss of species within parks, in part on the basis that NPS data were used and we did not believe these were adequate to draw such conclusions. We also could not tell whether we, as an agency, were meeting mandates of the Endangered Species Act because we did not know which parks had endangered species—or thought they did.

To respond to these deficiencies, systems called NPFLORA and NPFAUNA were initially developed. It was the first attempt by a federal land management agency to develop an agency-wide inventory of its species and to attempt an agency-wide standard for plant taxonomy. NPFLORA came first, driven by the establishment of a Washington program to implement the Clean Air Act and to know what park resources—especially vulnerable flora—existed in parks. To make the data more accessible, they were converted to a NPS database called COMMON. COMMON was on a mainframe and required dialing in for use, which made it difficult to use for parks with the technology of the time. In addition to access problems, for example, rapid cross-indexing of differing taxonomies was not available on-line.

Parks felt that this database was constructed largely to meet the needs of the NPS Washington Office. There was limited consultation with the field on the database structure, although plant checklists to populate NPFLORA were always obtained from park staff. COMMON was finally abandoned as parks turned to personal computers and rebelled against centralized mainframes—especially those that they did not view as useful. We tried having a third party construct and manage our species databases. That did not work too well either. And the utility of the system still eluded parks. Large parks often developed their own sophisticated databases that met their local needs better.

Many data were lost over the years without a successful national database that served as a forcing mechanism to archive them. This was amply demonstrated by the recent "data mining" efforts. These took place as a first step in conducting biotic inventories using the Park Service's new inventory and monitoring network approach. Yellowstone National Park (Idaho, Montana and Wyoming), Grand Teton National Park (Wyoming), and Bighorn Canyon National Recreation Area (Montana) discovered 1,500 voucher specimens collected in their units—collections they did not have records of—including vouchers for species they did not know occurred in there. This story was repeated over and over again.

And, 20 years after NPS started trying to look at the species it manages across the National Park System, we still do not have the data to do this, with the possible exception of threatened and endangered species.

Conclusion

But progress is being made. With the NPS inventory and monitoring program facilitating the acquisition of ever more data, for the first time parks began asking for help in trying to figure out how to manage those data—even, in some cases, asking for nationally required standard data fields. Almost all of the 12 working groups established to consider how to implement various components of the Natural Resource Challenge echoed the same request: help with data management. The prototype monitoring parks have perhaps made their greatest contribution to other parks through the interactions of the prototype data managers who have pooled their experiences, needs, and knowledge to help direct the development of more strategic approaches to data management. Web-based, easier-to-use technology has made a difference as well. And so has the substantial growth of skilled resource managers in parks, managers who understand science and the need for scientific data.

A more constructive and cooperative era has hopefully been entered, one that will result in strategic approaches to data management systems that can meet needs locally and globally. The Washington Office divisions within the NPS natural resources directorate are working together to develop compatible software programs within a common framework for better integration and sharing of data. The Natural Resource Information Division and its inventory and monitoring program are developing a series of Web-based master databases that are interlinked. For most of these, it is possible to download the latest version of the database and create a version in Microsoft Access that can be used locally and modified to serve the needs of the park. A Natural Resource Information Division position will be stationed in the Information and Telecommunications Division to facilitate integration with databases in other NPS program areas. Data management is receiving major emphasis in the inventory and monitoring networks. Indeed, even the establishment of these networks will facilitate a more strategic approach to data management as well as data collection.

To fully succeed however, each component of NPS needs to appreciate its role and importance in a broader context. We do not have the luxury of operating as individual units anymore. We need support of other units and neighbors and the National Park System as a whole to make a difference.

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55 Using community and museum collections to interpret industrial history

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Keweenaw National Historical Park was established in 1992 to commemorate the heritage of copper mining in Michigan's Keweenaw Peninsula and to work with numerous cooperating sites to tell stories of the mines, machinery, and people who were connected to one of the country's first and richest mineral rushes. The park is in the center of the Keweenaw, a small peninsula that extends about 80 miles into Lake Superior from Michigan's Upper Peninsula. The two park units, Quincy and Calumet, encompass historic industrial, commercial, and residential structures and landscapes situated along the Copper Range, a belt of copper-bearing rock that forms the spine of the peninsula.

This paper focuses on a unique opportunity to use significant one-of-a-kind resources to interpret the copper mining industry in the Keweenaw Peninsula. The industrial landscape in the Keweenaw is scattered with remnants of the past, hinting at a golden era long passed. The area has changed little to the outside eye, but is undergoing transformation as local preservation groups join efforts with the National Park Service (NPS) to revitalize the area through preservation of historic structures, landscapes, and material culture artifacts used to interpret industrial history.

Setting

The Keweenaw Peninsula is a rugged piece of land that is surrounded by Lake Superior on three sides. Winter can last seven months, with lake-effect snow accumulating up to 300 inches. One had to be hardy to survive here, especially in earlier times when limited transportation and communication during the winter months cut people off from the rest of the world.

The first people to mine copper in the Keweenaw Peninsula were Native Americans who collected surface copper and worked mass copper with hammer stones. Euro-American mining began on a significant scale following the Treaty of La Pointe in 1842, when the Ojibwa peoples ceded their lands in the western Upper Peninsula to the USA. Wealthy capitalists from the East Coast invested in speculative ventures that proved fruitful for some, and the rush to the "Copper Country" began in earnest. A period of development followed and, by the 1870s, mining companies up and down the Keweenaw were flourishing. Copper mining reached peak production between 1870 and 1910. Calumet & Hecla Mining Company (C&H), located in the village of Calumet, was the most successful company and the largest U.S. producer of copper during the 1870s. Quincy Mining Company, situated on Quincy Hill, was not as large as C&H, but was active in deep shaft mining from 1856 to 1931.

These companies had to rely on their own ingenuity and resourcefulness to be successful in such a remote location. Engineers and designers were obliged to develop innovative mining and processing equipment to support mine operations that sought native copper more than a mile beneath the surface.

One can only imagine the grandeur of Calumet during its heyday in the early 1900s when streets were crowded with people from all over the world. This remote mining town was transformed into a thriving economic center with shops, streetcars, movie theaters, an opera house, and electric lights. As many as 32 different immi-

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grant groups came to the Keweenaw to work the mines and provide various support services. Their distinctive languages, religions, customs, and habits transformed communities and resulted in a hugely diverse ethnic polyglot of people. Mining companies sought to control this diverse work force through paternalistic programs and service, including company-built housing and company-financed religious, medical, educational, and community facilities.

A bitter, year-long miners' strike in 1913-1914, and the high production costs associated with hard-rock mining, marked the beginning of a long decline. Readily available copper from open-pit mines in Butte, Montana, and Bisbee, Arizona, outcompeted the Copper Country mines. In 1945, operations shifted focus from mining to copper reclamation by recycling nineteenth-century tailings until the last mining company closed its doors in 1969. Mine closings had a dramatic effect on the local population: in the township of Calumet, numbers diminished from 40,000 in 1910 to 7,000 today.

The area's population had begun to decline after 1910 when company operations began to modernize and miners were laid off in great numbers. When the mines closed, more people left the area, leaving behind an abandoned infrastructure that was not well suited for other uses. Economic decline was so pronounced that redevelopment was out of the question. Businesses closed their doors, and others that had been situated in Calumet moved south to the nearby larger towns of Houghton and Hancock. Today, although Calumet and the neighboring village of Laurium only hint at their former prosperity, there are plenty of elderly folks who stayed in the area who remember what it was like during the heyday. After three decades of decline, populations are on the rise in the Keweenaw Peninsula. The area is attracting preservationists who are purchasing abandon historic structures for adaptive use. Development is also finding its way onto the Keweenaw, and once-abandoned mining towns are slowly being discovered.

Living laboratory

There are amazing quantities of families who have lived in this area for three and four generations. It is not uncommon to meet people who are living in the homes they were born in. A large number of elderly folks commute to warmer climes during the winter, yet they always return in the spring. Local people take pride in their heritage and the part they played in making their own history. In this sense, local residents are just as significant a resource as the material culture artifacts, structures, and historic landscapes they live among. The park has begun an active oral history program to preserve the history and stories surrounding hard-rock copper mining as it is remembered and told by community members, C&H employees, and their families.

There is an urgent need to capture information provided by the last two remaining generations that worked and lived in this area when copper mining flourished. Many interviewees are between the ages of 70 and 90 and the memories and stories they tell place local history in context and provide invaluable information to the community and researchers. Oral history information is also instrumental to park resource management goals, including interpretation, historical research, resource protection, preservation, and the rehabilitation of cultural landscapes and historic structures.

In addition to the people who comprise this living laboratory, there is a haunting industrial landscape all along the Keweenaw. Vestiges of a great mining era are present in the ruins of mine hoists and shaft houses, smokestacks, a large abandoned smelter complex, stamp mills, steam generating plants, and a reclamation dredge, in addition to structures that accommodated blacksmith shops, pattern shops, foundries, machine shops, and warehouses. Many historic structures are in various stages of deterioration, while local companies and businesses are adaptively using others of sound construction. Another component of the industrial landscape are large waste piles of poor rock, slag, and stamp sand scattered throughout the peninsula.

Calumet & Hecla library

Keweenaw National Historical Park recently made a decision to purchase five historic buildings in an effort to preserve the industrial core areas of the park in the Calumet and Quincy units. All the structures retain architectural and historical integrity. Two of these structures contain furnishings from the time they were occupied by their original owners. The C&H library (built in 1898) was a gift from the company to the diverse immigrant mining community. It contained three floors of stacks full of multilingual books, periodicals, and children's books, and two large reading rooms. The basement level was dedicated to public baths. The structure survives as an example of corporate paternalism practiced by C&H in their efforts to secure worker loyalty.

The C&H library building ceased to function as a library in 1944, when C&H managers and technical staff occupied the building until the company closed in 1968. Since then successor firms have occupied the building, and, remarkably, have left the historic fabric intact. Over a period of 30 years, a number of furnishings and archival materials were removed from the building; however, enough still remains to successfully interpret the structure as a functioning library and public space. Some of the historic furnishings and artifacts remaining in the library today are large drafting tables, layout tables with built-in flat files, a light table, library tables and chairs, roll-top desks, and a walk-in safe full of records, paintings, and geological specimens.

Quincy Mine office building

The park has also purchased the Quincy Mine office building (constructed 1895-1897) located in the Quincy unit of the park on Quincy Hill. The 5,000+-sq-ft structure, built of cut, coursed red sandstone, was the main office building for the Quincy Mining Company, and served as its employee pay house. Unlike the C&H library, only the ground floor has been occupied since the mining company closed in 1969. Currently the building is home to the George Wright Society offices as well as those of the Isle Royale Natural History Association.

The second floor and attic have been left dormant since 1969. Even today, though many furnishings have been sold, and people have sorted through and removed items they perceived as having value, the second floor and attic still retain an incredible amount of material culture artifacts and records. Some of these include a blue-print machine, a photography lab, layout tables, drafting tables, a tracing table, bookkeeping desks, chairs, drafting tools and office equipment, two walk-in safes, boxes of records, blueprints, maps, framed prints, and artwork. All these materials were left in place when the company closed its operations, almost as if the workers simply walked away and never returned. The park could create a historically furnished mining office using these artifacts with little effort since most of the furnishings are still in the building. Records associated with the Quincy mine office (apart from those that have been retained in the building) are located at Michigan Technological University's archives in Houghton. These records provide the historical background for placing the artifact collections in context and open the door for developing educational programming about corporate management of a Gilded Age workforce.

A salvage project is currently underway to sort through the contents of the second floor and attic, to separate thirty years of debris from the artifacts, assess their condition of the artifacts, and document and catalog them into the park's collection. All artifacts must eventually be temporarily removed from the building while it undergoes exterior and interior stabilization.

Pattern storage warehouse

Another example of objects being left in place when a mining company closed is the collection of C&H foundry patterns currently stored in a pattern storage warehouse located in a National Historic Landmark District in Calumet. C&H produced patterns from 1907 to 1968, accumulating an inventory of over 35,000. This one-of-a-kind resource representing mining industrial processes is severely threatened due to poor storage conditions. The wooden patterns were used to make molds from which industrial castings were produced. They range in size from a few inches square to ten feet in length, weighing up to 500 lbs. The pattern storage warehouse (built ca. 1885) has an internal roof drain that is failing. Water damage is a contributing factor for the collapse of a three-story internal shelving system that holds the patterns. Numerous patterns have water damage in the form of rot and mold, some patterns are split or broken, and many support the full weight of other patterns on the collapsed shelving. We believe there are over 10,000 patterns in the building; however, collapsed and rotting shelving prevent safe access and an accurate assessment of quantity and condition.

The significance of this collection is measured by its comprehensiveness, its condition, and its ability to contribute to the education of the public. The patterns are numbered and fully documented with design drawings located in the archives at Michigan Technological University and at the National Museum of American History at the Smithsonian Institution. Opportunities for using the patterns for interpretation have not been fully explored. The sheer quantity is a powerful statement about the scope of C&H operations. Individually, they are handcrafted works of art that retain the ability to explain many facets of mining technology, including power production, mineral extraction, ore reduction, preparation for shipment, maintenance, and replacement of equipment.

A project is underway to salvage the patterns from their present location. This involves renting heavy equipment to remove the patterns safely, constructing temporary shelving to house them, and employing a team of professionals to remove them so that their condition may be assessed before they are documented, catalogued, surface-cleaned, and stored appropriately. The C&H industrial pattern collection is unique in the USA in that it is one of the only remaining comprehensive collections of patterns specifically produced for a mining complex.

Preservation assistance and collaboration

This paper outlines a few of the opportunities that exist within park boundaries to develop educational and interpretive programming using material culture artifacts still located in their historic contexts. These opportunities will only be realized, however, through collaboration with local communities and park cooperating sites. This park is uniquely tied to a number of related state, regional, local, village, and township sites that all have one common goal—to educate the public about copper mining and life in the Keweenaw Peninsula. The park is a newcomer to the mix, having been established in 1992, although lack of funds the first five years meant there was no staff to develop programs. It is only recently that the park staff has expanded to an extent where we are able to collaborate more effectively, and also to provide more preservation and museum management services to the public and the cooperating sites.

At times, the glacial pace of federal planning, compliance, and budget processes frustrates local communities because they want to see results from the park after eight years of existence. The park is in an interesting position, representing the federal government within communities that were historically managed by corporate entities. We are in fact the most well-funded institution in the area, and this leads to perceptions that we are the only ones that can financially back a project, or save a collection or a structure. Federal dollars do get spread among community groups and cooperating sites; however, as park operations grow, competition for funds between our own projects and those of our partners becomes an issue. We need to develop criteria for funding community and partner projects, and coordinate these efforts with NPS projects to maximize limited resources. We also need to communicate, using press releases and a park newsletter, the kinds of preservation programs and projects we are working on and have programmed for the future. It is clear that our identity and what we do mean different things to different groups within the communities. It is in our best interest to clarify to the public exactly the kinds of services we can provide.

Building relationships and establishing rapport requires a strategy and a calculated pace. One of our strategies focuses on preservation outreach through a series of programs open to the public on the care of collections. Our goal is to engage the local community and cooperating sites about the value of their own collections, and to demonstrate the kind of information, resource networking, and professional assistance we can provide. Another strategy is to hold regular meetings with the park cooperating sites to convey our program goals and any new developments or projects we are involved in. This is also an opportunity to see what the individual sites are doing and what needs they may have for training and collaboration. It is also critical that we visit each of our cooperating sites during their limited open seasons to gain a better understanding of the issues or preservation dilemmas they contend with on a daily basis. We need to share resources and expertise to achieve common goals. It will take time, but building strong relationships with park partners is critical to the success of using local historic resources to promote research and interpretive programming.

Summary

Interpretive programs have yet to be developed at Keweenaw National Historical Park, but we hope to hire a chief of interpretation during the next fiscal year. Our task is to lay the groundwork, not only by identifying collections, but also by developing rapport with members of the community and with park cooperating sites. Resources have been identified in the recorded memories people share, in the artifacts scattered throughout the industrial landscape, and in historic structures and the artifacts they contained—as well as in the minds and hearts of the residents who are proud of their history and want to share it. The Keweenaw Peninsula is fertile ground for using community and museum collections to interpret industrial history.

56 Using economics to inform national park management decisions: a case study on the Blue Ridge Parkway

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Introduction

National parks frequently face difficult budget decisions. Economics can facilitate making these decisions by suggesting that benefits and costs should be weighed in order to make efficient budget allocations. However, this is often difficult in national parks since many park resources and amenities, such as scenic beauty and species preservation, are not priced in markets. At the same time, it is costly to maintain these resources. In effect, park managers face these costs in dollar terms, but not the benefits. Nonmarket valuation is a tool of economics that can help alleviate this problem by estimating the value of resources and amenities that are not exchanged in markets. This paper introduces the tools of nonmarket valuation and demonstrates how they can be used to inform park decisions. In addition, a case study on the Blue Ridge Parkway is presented which demonstrates how nonmarket valuation data can be used to inform decisions in that park.

Background

National park budgets, like most budgets, are limited. This implies a need for budget scrutiny. Economic efficiency criteria requires that benefits and costs of alternative budget decisions be weighed. For national park managers, this may take many forms:

- Do the benefits of a specific park initiative or program exceed the costs? (Benefit–cost analysis.)
- For a given set of priorities or directives, what is the cheapest method of achieving them? (Cost effectiveness analysis.)
- Given a park mission, what is the best use of the budget?

Weighing the costs and benefits of alternative policies provides information about the efficiency of those decisions so that scarce dollars can provide maximum benefits to park users. Turner (2000) provides a model showing efficiency criteria that can be used by park officials in determining entrance fee levels and resource allocation levels for multi-attribute park experiences. However, he notes that the valuation information needed by park officials is not readily available to implement these decision criteria. Nonmarket valuation can be used to fill this information gap.

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While it is relatively easy to calculate the costs of decisions, it is unfortunately more difficult to estimate the benefits of many decisions that park managers need to make. This is because public goods such as scenic beauty, habitat preservation, and ecosystem services are not frequently exchanged in markets so observable prices and demand curves for these goods and services do not exist in many cases. This does not mean, however, that people do not have preferences for these goods and services. The economic tools of nonmarket valuation are designed to estimate the values of the goods and services that are not readily exchanged in a market.

Types of nonmarket valuation

Clawson (1958) reported that an early national park study indicated concern about methods for placing a monetary value on recreation since those methodologies appeared to be somewhat arbitrary (Prewitt 1949, cited in Clawson 1958). In the last half-century, however, the methodologies for estimating nonmarket values have been significantly advanced and are now quite commonly used.

One type of method used to uncover these underlying preferences for environmental resources associates consumption of a related market good in order to estimate the value of the nonmarket good or service. For example, one might incur travel costs in order to enjoy scenic beauty. This technique is categorized as a revealed preference method since consumer preferences are "revealed" through their consumption of a complementary good or service. A common revealed preference approach used to estimate values for recreational sites is the travel cost method. This method assumes that expenses incurred to make a visit to a recreational site express one's value of the site. However, complementary market goods or services that adequately reveal consumer behavior are not always available; thus the contingent valuation approach was developed.

The contingent valuation method is sometimes referred to as a "direct" approach to estimating willingness to pay since it involves directly asking individuals to state their preferences for some characteristic of the environment or natural resource in question, i.e., state their willingness to pay. For example, what is the most you would be willing to pay in order to recreate in Yosemite National Park? It is "contingent" valuation because it asks people how they would act if they were placed in certain possible situations. In contrast with revealed preference methods, the stated preference method of contingent valuation does not use actual observed market behavior as the basis of benefit measurement. Contingent valuation has been used extensively in measuring the benefits of a variety of public goods, especially environmental quality. This is likely due in great part to the flexibility and applicability of the methodology, since contingent valuation can be tailored to study "virtually anything that can be made comprehensible to respondents" (Field 1994, 151). This includes goods and services such as the existence value for endangered species (Boyle and Bishop 1987; Bowker and Stoll 1988). Variations on the contingent valuation method include contingent ranking and contingent choice surveys, where respondents rank and select their preferred outcomes, respectively.

Choice modeling is another stated preference method that can be used to estimate values for goods such as scenic beauty and recreation services (Adamowicz et. al. 1997). A choice modeling study presents respondents with a series of choices about a respondent's preferred alternative with regard to the amenity. For example, each choice can represent a different park management option. Each management option will represent different levels of park attributes, including the entrance fee, number and condition of hiking trails, level of scenic quality, number of campsites, miles of paved roads, and the like; one of the options will describe the current state of the park. Respondents then "state" their preferences by choosing the alternative they most prefer. By analyzing the results of a series of these choices made by many individuals, it is possible to estimate an implicit price for each attribute (e.g., number of campsites).

In addition to the travel cost, contingent valuation, and choice modeling methodologies, the hedonic price method can be used to estimate the value of living near an amenity such as a park. This approach has limited applications to the national parks due to the narrow focus of values estimated from residential property values associated with living near a park.

In sum, there are several nonmarket valuation methods available to aid decision-makers; each has its strengths and limitations (Freeman 1993; Hausman 1993; Smith 1996). Since the choice of appropriate method will depend inherently on the specific situation at hand, the following section will discuss how nonmarket valuation can generally be applied to park management decisions.

Using nonmarket valuation to inform park management decisions

As Turner (2000) noted, important valuation information is needed for park decisions, especially when parks provide many alternative activities for visitors. There are several questions that must be considered before undertaking a nonmarket valuation study in a national park.

- Are nonmarket goods or services involved that should be included in the decision process?
- Is it desirable to have the value of these goods and services monetized so that they can be compared with other alternatives?
- Is the park willing and able to take time and money to analyze these goods and services?
- Does the good or service provided by the park encompass multiple dimensions (e.g. scenic viewing, hiking, boating, fishing, wildlife habitat, etc.)?
- What type of value is needed: whole (visitor value of entire range of experiences) or partial (hiking experience, or wildlife habitat)?

Park managers may want to include in their decision process values of park resources that are not available from typical sources such as entrance fee collections and satisfaction surveys. For example, in many parks a significant component of a visitor's experience may include resources whose value is typically not captured in normal operations, such as scenic beauty, ecosystem services, and wildlife habitat. Costs have to be incurred in order to preserve these aspects of the park experience. Examples include costs associated with habitat preservation or restoration, the purchase of conservation easements, and the like. Nonmarket valuation can be used to measure the benefits from this aspect of the park experience: for example, a contingent valuation study can estimate the benefits of preserving the habitat to compare with costs of preservation.

Alternatively, a nonmarket valuation study may be useful if a park is considering implementing an entrance fee, or raising an existing entrance fee. Data from a contingent valuation study can help determine visitors' willingness to pay the new fee, whether or not visitation will be affected, and the like.

Finally, if individuals wish to preserve the option of visiting a park—even if they haven't yet made a visit, or may not ever actually make the visit—then option values could be incorporated with the benefits accruing to visitors of the park (Walsh and McKean 1999). These option values may be significant for those parks with particularly unique resources and amenities.

In the above cases, nonmarket goods and services exist that may be valued for the decision process. Park officials must then decide that they want to place monetary values on these goods and services and are willing to allocate funds to estimate these values. The method used depends upon the characteristics of the goods and services valued and the decisions facing park officials. It is important to remember that each park's challenges are unique and the application of nonmarket valuation to improve decision-making is not uniform. The Blue Ridge Parkway example below illustrates how these methods are being applied in a particular park.

Case study on the Blue Ridge Parkway

The Blue Ridge Parkway, a unit of the National Park System, is a scenic motor road connecting Shenandoah National Park in Virginia with Great Smoky Mountains National Park in Tennessee. Addressing the concern for the decline in scenic quality along the Blue Ridge Parkway requires that the park allocate scarce resources for view preservation, such as paying for increased vegetation management, or purchasing conservation easements, leases, or land. Blue Ridge Parkway staff currently use a descriptive ranking system of sites to identify critical sites for preservation (Johnson, Orr, and Rotegard 1997). This determines which sites are threatened and which sites visitors consider to be of highest, medium, or low quality. It does not tell the park which sites visitors are willing to lose, or if visitors are willing to give up trails and campsite quality to maintain or improve scenic quality. Parkway officials know what it costs to preserve views; they do not know the benefits. Nonmarket valuation provides critical information to the decision process for park staff when making resource allocation decisions. Introducing consumer preferences into the decision process by using benefits estimation provides estimates that are comparable to mitigation costs.

Given the needs of park staff, we used choice modeling and a variant of a contingent valuation survey, a contingent choice survey, to analyze visitor preferences towards the attributes of their recreation experience and the impact of changing scenic quality on visitor trips to the Blue Ridge Parkway.

The choice modeling survey elicits information about whether visitors prefer more hiking trails, overlook areas, roadside landscape management, or some combination of these services. In addition, by using a monetary attribute in the survey we can estimate the benefit for each attribute and of maintaining the current quality of scenic views along the Blue Ridge Parkway by estimating visitors' willingness to pay. The contingent choice survey used view quality to elicit expected changes in visitation behavior if alternative quality levels occurred. Several scenarios representing both increases and decreases in quality were presented to each respondent, and respondents were asked to state their level of visits in response to the alternative. This data will be used in combination with expenditure data (Brothers and Chen 1997) in order to estimate the economic impact of these changed visit levels.

Three formats of the survey were implemented on the southwest Virginia section of the parkway. Implementation occurred at Mabry Mill, the most visited site on the parkway. Computers were used to administer the survey; paper copies were available for those who preferred that medium. During summer and fall 2000, 860 observations were collected over several weekend and weekday periods.

Preliminary results

Statistical analysis of survey responses is not yet complete; results will be available by January 2002. However, an examination of some preliminary results can shed light on how these may be used in park management decisions.

Some respondents (n=245) were asked if they were willing to pay a randomly assigned amount ranging from $5 to $200 in order to ensure their Blue Ridge Parkway experience. For values between $5 to $125, at least 60% of all respondents indicated a yes response (37% of those offered $200 answered yes). A follow-up question asked respondents to identify the most they would be willing to pay this year in order to ensure their experience on the Blue Ridge Parkway next year. On average, these respondents indicated a maximum willingness to pay of $121. This suggests that many visitors to the Blue Ridge Parkway—who do not pay an entrance fee—would be willing to do so in order to ensure their experiences on the parkway were maintained. This is the type of information that may be useful to managers in parks considering access or user fees.

Preliminary analysis also indicates a majority of respondents would be willing to pay in order to enhance their scenic experiences on the Blue Ridge Parkway. Specifically, if given a choice between the status quo experience, with no fee, or one that included an improvement in roadside and overlook scenic quality with a supplemental $50 annual fee, 69% of the time people would choose to pay the fee to improve scenic quality. Further analysis will allow us to calculate the incremental value of these improvements, along with the incremental value of changes in hiking trails, activity areas, and number of overlooks. This information will be useful for staff members of the Blue Ridge Parkway since they will be able to estimate the value to visitors of making various changes in their management plan, and compare these benefits to the costs of making such changes.

Conclusion

The economic tools of nonmarket valuation are designed to estimate the values of the goods and services that are not readily exchanged in a market, such as the value of a natural soundscape or visibility. Estimating these values can provide important information to the park manager. While each park will face different decisions and thus have different information needs, the Blue Ridge Parkway example provides a case of applying these methods to park management decisions. Parks face several challenges if they decide to use these methods. Perhaps most daunting will be finding the money and expertise needed to conduct the survey and accompanying analysis. In addition, since each study is unique, it is time-consuming to do effective nonmarket valuation studies—expect a minimum of one-and-a-half to two years from conception to implementation.

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57 External economic pressures and park planning: a case study from Dominica

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Established in 1975, Morne Trois Pitons National Park protects one of the most spectacularly rugged landscapes in the Caribbean. Situated on the island of Dominica, the 17,000-acre park encompasses a variety of habitats ranging from lowland tropical rainforest to high-elevation elfin woodland. Much of the area is nearly impenetrable, characterized by dense forest cover and precipitous slopes. A series of steep-sided volcanic cones flanked by eroded lava flows and ash deposits dominate much of the park's interior. The highest of these volcanic peaks, Morne Trois Pitons, rises to an elevation of 4,672 feet within five miles of the ocean.

The high peaks and ridges of Morne Trois Pitons National Park form a barrier to the easterly trade winds, delivering tremendous quantities of orographic rainfall to the center of the island. Many interior park locations receive more than 300 inches of precipitation annually (Evans and James 1997). This combination of high rainfall and rugged terrain gives rise to an abundance of water resources and some of the most spectacular waterfalls in the Caribbean (Torres et al. 1998). Roughly half of Dominica's drinking water comes from streams that originate inside the park.

In 1998, Morne Trois Pitons was added to the global list of United Nations World Heritage Sites. It is the only terrestrial world heritage site in the Caribbean designated solely on the basis of its outstanding natural features. Much of the justification for this designation was based on the unambiguous role of the park in protecting biological diversity. Morne Trois Pitons supports a number of plant and animal species that are endemic to Dominica, including a bromeliad *(Pitcairnia micotrinensis),* a tree frog *(Eleutherodactylus amplinympha),* and two species of parrot: the imperial parrot (or sisserou) *(Amazona imperialis)* and the red-necked parrot *(Amazona arausiaca)* (Christian et al. 1994; Evans and James 1997). It also provides an important habitat for other rare species such as the blue-headed hummingbird *(Cyanophaia bicolor),* which is endemic to the Lesser Antilles.

The diverse assemblage of biological resources protected by the park is complemented by an equally impressive array of unique geological attributes. Active geothermal features are common throughout Morne Trois Pitons, reaching their most spectacular expression in the area of Grand Soufriere (the Valley of Desolation). Boiling pools, fumaroles, and mineral-laden streams of varying colors and temperatures create a unique, treeless landscape. Much of the area is covered with mosses, bromeliads, and grasses that are uniquely adapted to the harsh growing conditions. The Boiling Lake, located in the center of the park, is the second largest lake of its kind in the world.

Primary responsibility for the management and protection of Morne Trois Pitons National Park rests with the Forestry, Wildlife, and Parks Division of the Ministry of Agriculture, Planning, and the Environment. Established in 1949 as the Dominica Forest Service, the Division is responsible for the protection of the island's natural resources, including its parks, forests, wildlife, watersheds, and soils (Forestry and Wildlife Division 2000). Concomitant with its mandate to protect the country's re-

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sources, the Forestry Division also plays an active role in educating the public on issues of conservation and sustainable resource use.

Consequently, conservation and park management issues maintain a remarkably visible presence in Dominican society. The 1998 designation of Morne Trois Pitons as a world heritage site made front-page headlines in each of the country's major newspapers. Much of this environmental awareness can be attributed to the diligent work of the Forestry Division. The effectiveness of this agency is further illustrated by the fact that roughly two-thirds of the island remains in natural forest cover, a rate higher than that of any other Caribbean nation (Evans and James 1997).

In the creation of Morne Trois Pitons National Park the people of Dominica demonstrated a strong commitment to environmental protection (Wright 1985). However, there are a number of emerging issues that may have a significant impact on the long-term integrity of the park. It is now well recognized that many of the most significant threats to protected areas worldwide originate far from park boundaries. Whether it is the illegal wildlife trade in the national parks of Asia, or illegal drug cultivation in the national parks of South America, natural resource managers increasingly face threats that are beyond their control (Terborgh 1999).

Morne Trois Pitons National Park is a clear case of distant and powerful forces setting in motion changes that threaten the very existence of a protected area. In this case, tiny Dominica is caught in the middle of an economic dispute between two huge trading blocks, namely the USA and the European Union. This dispute is totally unrelated to environmental protection, yet its unintended side effects may have a profound effect on natural areas throughout the Caribbean.

This dispute is ostensibly over bananas. In 1993, European nations created a system of quotas for the importation of bananas into the European Union (Sanger 1999). These quotas were intended to benefit the former Caribbean and African colonies of the European powers while restricting the importation of bananas from Central and South America. In practice, the system secures about 20% of the European market for the former colonies while Latin America supplies the remainder (Ferguson 1998). Both the Europeans and the former colonials contend that small-scale banana growers in the Caribbean and Africa cannot compete with the large, vertically integrated producers in the Americas.

The USA became involved in this dispute in an effort to eliminate the quotas, which were seen as a barrier to free trade. Of course, there is no banana export industry in the USA. Yet, it is the USA that precipitated a minor trade war with Europe by bringing several complaints to the World Trade Organization (WTO) in the late 1990s (De Palma 2001a). The USA prevailed at the WTO, and the Europeans were ordered to abandon the quotas. After the European Union refused to lift the quotas, the USA was authorized to retaliate, which it did by imposing 100% tariffs on such diverse and unrelated European luxury goods as Louis Vuitton handbags, Scottish cashmere sweaters, and Parma ham (Sanger 1999).

The key to understanding why the USA intervened "is steeped in American politics" (Sanger 1999). More specifically, the manner in which the USA finances its presidential elections is the crucial element. While the USA has no direct stake in bananas, Carl Lindner does. Lindner, owner of the Cincinnati Reds baseball team, is also chairman and chief executive of Chiquita Brands International, a transnational corporation that owns and operates vast banana plantations in Central and South America. Between 1993 and 1996, Lindner donated more than $1,000,000 to the Democratic Party while also contributing significantly to the Republicans (Ferguson 1998). In the year preceding the presidential election of 2000, Lindner "contributed $550,000 to the Republican Party and at least $275,000 to the Democrats, according to public financing records" (De Palma 2001a).

In the wake of the WTO decision, the Europeans had proposed several compromises that were rejected by Chiquita and the USA. According to the *New York Times*, "Chiquita pushed Washington to respond aggressively and backed its demands with substantial contributions to both political parties from its chief executive, Carl H. Lindner" (De Palma 2001b). Finally, in April of 2001, the impasse was broken when the Europeans agreed to import more bananas from Latin America. The new accord uses a complex formula that should help Chiquita regain the 40% share of the banana market it enjoyed prior to 1993 (Cooper 2001). Ironically, Chiquita already has the largest share of the European banana market (Lavery 2001). In 1998, Chiquita supplied 25% of European bananas while the entire Windward Islands Group accounted for only 6% (Ferguson 1998).

Although banana exports from the eastern Caribbean represent only a minor fraction of Europe's supply, the banana industry is of primary importance to the economic stability of the Windward Islands. For example, in Dominica bananas account for more than half of all export earnings and 36% of the national labor force (Godfrey 1998). The negotiated increase in Chiquita's share of the European market will certainly come at the expense of small producers in the eastern Caribbean. According to Paul Reillo of the Rare Species Conservatory Foundation (a conservation group working closely with the government in Dominica), the anticipated loss of banana subsidies may catalyze a significant decline in agricultural revenues for the entire eastern Caribbean (Reillo 2001). Thus, decisions made far from the Caribbean are creating an increasingly dire economic landscape in the region. Consequently, protected areas are increasingly exposed to encroachment from subsistence farmers, tourism entrepreneurs, and extractive industries.

In Dominica, the past few years have witnessed a number of proposals for environmentally damaging development projects financed by foreign investors. Most notable among these was a proposal for a large copper mining operation in the heart of the island's interior forest reserves. This project, initiated by an Australian mining company, would have covered 10% of Dominica's land surface area. Conservationists, led by the Dominica Conservation Association (DCA), responded with a local and international campaign to halt the initiative. As a result of this successful campaign, Atherton Martin, head of the DCA, was awarded the prestigious Goldman Environmental Prize in 1998.

A more immediate threat to Morne Trois Pitons National Park is the recently initiated construction of an aerial tramway on the forested slopes just west of the park boundary. This project, financed in part by external investors, was originally designed to transport visitors into the core area of the park. However, early on it became clear that the environmental impacts of the project, both physical and visual, were unacceptable. A series of informal discussions between World Heritage representatives and the Dominican government led to a relocation of the tramway outside the park boundary. In this case, the park's status as a world heritage site played a major role in keeping the aerial tram out of the park. Nonetheless, this project may still have a major impact on the forested habitats immediately adjacent to the park boundary. Although construction is currently suspended due to a lack of funding, the issue remains unresolved.

Another simmering issue is the proposal to construct a new international airport on the northern end of the island. There are presently two airports in Dominica, neither of which can accommodate direct flights from the USA or Europe. The goal of the proposed airport is to significantly increase the number of visitors to the island. Some see this as a key element in enabling tourism to replace bananas as the country's leading foreign exchange earner. Others fear that a major increase in tourism would overwhelm the island's protected areas and undermine the perception of Dominica as "the Nature Island." Although the airport is currently under review, many still see this as a pivotal issue. Attorney Henry Shillingford of the DCA has stated that "if this airport is built, all of our work here will be for nothing" (Shillingford 1999).

The vulnerability of Dominica's national parks and protected areas is directly related to the vulnerability of its economy. Since the arrival of the Europeans more than 500 years ago, Dominica and its neighbors have struggled to control their own economic destinies (Honychurch 1995). The present course of economic globalization has only served to exacerbate this situation. As the St. Lucia Minister of Commerce, Industry & Consumer Affairs has stated: "Globally, we're just a lonely pawn on a gigantic chessboard surrounded by kings, queens and rooks who are waiting their moment to pounce" (Royle 2001). Although the ongoing struggles to curb campaign finance abuses and rethink the globalization project may seem peripheral to the management of national parks, they are integral to the fight to save the world's remaining wild places.

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58 NPS Management Policies 2001

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The latest edition of the National Park Service (NPS) management policies (2001) was approved in December 2000. It builds upon the framework of the 1988 version, while allowing NPS to keep pace with new laws, changes in technology and American demographics, and new understandings of what we must do to protect the natural and cultural resources of the national parks. As the foundation document for the NPS directives system, it is intended to serve as a reference manual to aid in policy searches.

Several key updates are based on the National Parks Omnibus Management Act of 1996 (P.L. 104-333) and that of 1998 (P.L. 105-391), various provisions contained in appropriations acts, and other laws and executive orders enacted since 1988. New concepts and topics have been added or expanded, such as sustainability and environmental leadership, management accountability, managing information resources, "partnering" with others to help protect parks and serve the public, and dealing with management challenges that originate outside park boundaries.

A key section of the new management policies that was discussed during the George Wright Society conference concerned park management and the impairment issue. For many decades NPS has provided opportunities for enjoyment without impairing park resources and values, and we will continue to do so. Updates on the impairment issue and other helpful information can be found on the World Wide Web at http://www.nps.gov/protect. The following compilation, created by Chick Fagan, program analyst in the NPS Office of Policy, gives answers to many of questions that came up during the conference regarding park management in Section 1.4 in the 2001 management policies.

Why is the "impairment" issue so important?

Eighty-five years ago, President Woodrow Wilson signed into law the NPS Organic Act. There is an important provision in the law that tells us the purpose for which we manage the national parks:

> …which purpose is to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations.

This is our core mission in managing the parks. Since passage of the act, we have had recurring discussions among ourselves—and with others—over what it means. We have often characterized the Organic Act as giving us a "contradictory mandate" that requires us to perform a "balancing test"—balancing between resource protection and public enjoyment. But we have argued at other times that it is *not* a balancing test—that resource protection is paramount. In short, we have not had within NPS a

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common and consistent interpretation of our mandate under the Organic Act. This has led to inappropriate and, at times, illegal decisions being made with respect to park resources and values.

Why are we now focusing so intensely on the "no-impairment" clause of the Organic Act?

Arguments about the "contradictory mandate" have sometimes led us into the courtroom. One of the more recent court cases occurred at Canyonlands National Park and Glen Canyon National Recreation Area, where the parks had prepared a backcountry management plan (BMP). Informally referred to as the SUWA (for "Southern Utah Wilderness Alliance") case *(SUWA v. Dabney)*, it has caused us to scrutinize, perhaps more closely than we have in the last 85 years, each and every word in the Organic Act. The following is a very brief summary:

- The administrative record showed that levels of motorized vehicle use were increasing, and the use was adversely affecting park resources.
- The draft BMP included a preferred alternative that would have eliminated off-road vehicle (ORV) use on a 10-mile segment of Salt Creek Road in Canyonlands.
- The administrative record showed that Salt Creek was the only perennial freshwater stream in Canyonlands.
- The ORV user groups were very distressed by the proposed closure.
- The park then adopted a plan that would allow some limited continued use under a permit system, while conducting monitoring and assessment activities that would determine whether the reduced level of use still caused harm to the area.
- The park was then sued by the Southern Utah Wilderness Alliance on the ORV issue and several other issues. The ORV groups intervened in support of the NPS decision.
- The park won on most of the issues, but lost on the Salt Creek issue.

The District Court decision. In these kinds of cases, the court applies what the Supreme Court has established as the "Chevron 2-step test" (named for the case known as *Chevron U.S.A., Inc. v. Natural Resources Defense Council, Inc.*) to determine whether an agency's reading of a statute it administers is correct. Under step 1, if Congress has spoken to the precise question at issue, then that controls the court's—and the agency's—interpretation of the statute.. At that point, there is no need to go to step 2. However, if the statute is silent or ambiguous, the court defers under step 2 to the agency's interpretation so long as it is a reasonable interpretation of the statute. Our defense contended that Canyonlands was a "Chevron 2" case, whereby we are allowed to strike a balance between competing mandates of resource conservation and visitor enjoyment. The District Court ruled where there is "permanent impairment of unique park resources," then the Organic Act is not ambiguous: the activity cannot be allowed. The District Court ordered that the park could not allow motorized vehicle use on the 10-mile section of trail.

The appeal. The ORV groups then appealed the District Court's decision. This caused NPS to consider whether the court had properly articulated the standard for determining when the agency is in violation of the Organic Act. The timing of the ruling allowed the office of the assistant secretary of the interior and NPS to consider the issue in the context of the revision of the new management policies (in which Chapter 1 outlines the legal and philosophical foundations of the National Park System) and use the SUWA case as an opportunity to articulate an official Department of the Interior (DOI) and NPS interpretation of the Organic Act. So we filed a brief to advise the court of DOI's views on the proper interpretation of the Organic Act. This interpretation was *different* from that which we had offered previously, wherein we contended that the law authorizes NPS to balance between competing mandates of resource conservation and visitor enjoyment.

Since the policy interpretation offered by DOI was technically still in draft form (the 2001 management policies had not yet been approved), the Court of Appeals did not consider the position we offered. But it also said that the District Court erred in its decision, and found that:

- The Organic Act is a Chevron 2 case, not a Chevron 1 case.
- ORV use is not explicitly prohibited by the Organic Act.

The court also said: "We read the Act as permitting the NPS to balance the sometimes conflicting policies of resource conservation and visitor enjoyment in determining what activities should be permitted or prohibited." But the court added: "The test for whether the NPS has performed its balancing properly is whether the resulting action leaves the resources 'unimpaired' for the enjoyment of future generations."

The park is now re-working that portion of the BMP addressing Salt Creek Road in light of the court's decision. It has closed the road pending a new environmental assessment. The environmental assessment will consider the ongoing studies and monitoring that have taken place on the road since the district court closed it in 1998. The environmental assessment will also include an impairment finding, as required by the management policies and the NPS Director's Order #12.

Since similar lawsuits have been adjudicated before, why has the SUWA case been singled out?

The SUWA case has become the focal point for the no-impairment issue mainly because it is the first case to find that NPS had violated the Organic Act by not protecting park resources and, in doing so, it articulated a new standard for finding such a violation. It also became a focal point of the no-impairment issue because the court's decision coincided with our re-drafting of the management policies, allowing us to determine whether we should adopt the court's standard or not. In focusing on the SUWA case, we must resist the temptation to be overly judgmental. The decisions that were made there, and the political realities and tensions that the superintendent had to deal with, are mirrored all across the National Park System. Making the right decisions under those circumstances is difficult at best; being a Monday-morning quarterback is always easy. But we know that park-level decisions sometimes have Servicewide repercussions. The main point is that we all learn as much as we can from these sorts of lessons.

Where does this now leave the rest of NPS?

Even though the interpretation of the Organic Act we offered to the Court of Appeals was not considered because it was not final, we continued to work on it, under the leadership of the assistant secretary's office. Initially, we adopted our interpretation as Director's Order #55. But that was superseded by Section 1.4 ("Park Management") of the new management policies, approved December 22, 2000. Thoughtful consideration was given to virtually every word in Section 1.4. The policy's wording was selected—or not selected—for important reasons, namely:

- To leave as little room as possible for misinterpreting or deviating from the course it sets;
- To help ensure that we are consistent in the way we make decisions;
- To show the courts we have thoroughly thought through the instructions given to us in the Organic Act; and
- To convince the courts in future challenges that our interpretation is logical and reasonable, and should be shown deference.

What does Section 1.4 of the management policies say?

Section 1.4 tells us that:

- The no-impairment requirement of the Organic Act and the no-derogation requirement of the Redwood Act amendment define a single standard for management of the parks, and the terms can be used interchangeably.
- In addition to avoiding impairment, we have an ongoing responsibility to conserve park resources and values.
- The fundamental purpose of all parks also includes providing for the enjoyment of park resources and values by the people of the USA.
- "Enjoyment" means enjoyment both by people who directly experience parks and by those who appreciate them from afar, and includes more than recreation.
- When there is a conflict between conserving resources and values and providing for enjoyment of them, conservation is to be predominant.
- NPS has management discretion to allow certain impacts within parks, but not to allow impacts that would leave resources and values impaired (unless Congress explicitly provides for the impairing activity).
- Whether an impact would harm the integrity of park resources or values is a decision left to the responsible NPS manager.
- Impairment may occur from visitor activities, NPS activities in the course of managing a park, or activities undertaken by concessioners, contractors, or others operating in the park.
- Park resources and values include virtually all cultural resources and all natural resources and processes, as well as opportunities to experience enjoyment of them.
- Ongoing activities that might have led or might be leading to an impairment must be investigated and, if there is or will be an impairment, the impairment must be eliminated as soon as reasonably possible.

How will we implement this new policy?

For some in the Park Service, this interpretation is not really "new." Many have operated under the assumption that the law means what it says—we cannot take actions that impair park resources. But Section 1.4 formally adopts a single interpretation that everyone must live by. And the basic framework has been in place for a long time.

- For more than 30 years, we have been required by Section 106 of the National Historic Preservation Act to take into account the effects our proposed "undertakings" will have on National Register or Register-eligible sites.
- For more than 30 years, we have had the National Environmental Policy Act (NEPA) requirement that we address the effects of our actions on the human environment.
- For nearly as long, we have had procedures in place to address these requirements.

But Section 106 and NEPA require merely that we fully analyze and disclose the adverse consequences of our proposed actions. As long as we take all the steps required under those laws, and do the best we can to mitigate or avoid adverse impacts, they allow us to pretty much do whatever we want. And that is why the clear, unequivocal interpretation of Section 1.4 is so important to us: it requires one more critical step in the decision-making process. We must ask the question: Is the impact of this action going to be so bad that it will *impair* park resources or values? If the answer is "yes," then we cannot undertake the action.

Does this mean that everything we do will be an impairment, and therefore we cannot do anything that will affect park resources or values?

No, it does not mean that. As stated in Section 1.4.3 of the management policies:

> T]he laws do give the Service the management discretion to allow impacts to park resources and values when necessary and appropriate to fulfill the purposes of a park, so long as the impact does not constitute impairment of the affected resources and values.

Furthermore, Section 8.1 of the management policies states:

> The fact that a park use may have an impact does not necessarily mean it will impair park resources or values for the enjoyment of future generations. Impacts may affect park resources or values and still be within the limits of the discretionary authority conferred by the Organic Act.

We must recognize that there are many types and degrees of impact. Some impacts may be beneficial, while others may be adverse. Some of the adverse impacts may be so adverse as to significantly affect the quality of the human environment. When they reach that level, NEPA requires that an environmental impact statement be prepared. When a significant adverse impact reaches the level of impairing park resources or values, it is prohibited under the Organic Act.

How do we distinguish an impact that is adverse from one that would constitute an impairment?

This is the most difficult task we now face. Section 1.4.5 says the impairment that is prohibited:

> [I]s an impact that, in the professional judgment of the responsible NPS manager, would harm the integrity of park resources or values, including the opportunities that otherwise would be present for the enjoyment of those resources and values. Whether an impact meets this definition depends on the particular resources and values that would be affected; the severity, duration, and timing of the impact; the direct and indirect effects of the impact; and the cumulative effects of the impact in question and other impacts.

An impact would be more likely to constitute an impairment to the extent that it affects a resource or value whose conservation is:

- Necessary to fulfill specific purposes identified in the establishing legislation or proclamation of the park;
- Key to the natural or cultural integrity of the park or to opportunities for enjoyment of the park; or
- Identified as a goal in the park's general management plan or other relevant NPS planning documents.

"An impact would be less likely to constitute an impairment to the extent that it is an unavoidable result, which cannot reasonably be further mitigated, of an action necessary to preserve or restore the integrity of park resources or values" (Section 1.4.5).

Rarely will there be clear-cut evidence that impairment will occur. Superintendents and other decision-makers must apply their professional judgment to the facts of each case, taking into account technical and scientific studies and other information provided by subject-matter experts within and outside NPS. We are in the process of developing the criteria and understandings we will need to carry out this responsibility efficiently. This is being done mainly by a task force with natural and cultural resource expertise.

Reference

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59 Paleontology data and NPS collections: unbounded resources, or, between managers and scientists

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Introduction

Curation is at an interesting crossroads in the National Park Service (NPS). Museum collections in NPS are, in effect, divided into two main categories: (1) The culture and artifacts of one species *(Homo sapiens)*, and (2) everything else in the universe. Natural history collections make up less than 2% of the national catalogue, reflecting inattention to these elements of natural resources management, and a disregard resulting from the lack of professional scientific curators. The majority of the policies and procedures in use were designed by culturally attuned museum professionals, with limited input from scientists.

Is NPS headed in the right direction with natural history museum specimens? There is uncertainty over the status of collections and the desired role of other national repositories for the tremendous variety of biological and geological objects. Has the agency become so procedurally rich and knowledge-poor that it is alienating national museums and scientists? Perhaps paleontology, one of the more esoteric disciplines within natural history, can provide perspectives of interest to neobiological curators concerned with NPS collections programs.

Paleontology and natural history collections

The subject of paleontology is a useful lens for scrutinizing many natural history collections issues. No discipline relies more completely on systematic museum collections as the field of paleontology, particularly vertebrate paleontology.

Paleontologists prospect in time for representatives of ancient ecosystems, bringing evidence back for curation in systematic storage. The ancient biotas are entombed in strata reflecting depositional environments, absolute ages, lithologies, and much more. These associated inorganic materials are deposited in collections as "geology" specimens. The collectable fossils range from enormous materials weighing many tons, to microscopic trace fossils visible with scanning electron microscopes. They include preserved material from virtually all higher taxa of organisms, the vast majority of which are extinct. But, like modern ecological assemblages, taxonomic samples are only a small part of the collection effort. Associations of taxa; variation in spatial communities; temporally continuous records of clades at various evolutionary stages; paleoclimatic indicators, such as paleosols; and hundreds of things such as trackways, coprolites, dental tartar, pollens, and much more—all inhabit museum cabinets.

Detailed notes accompany any collecting. These typically are catalogued as "archival" materials. The fossils are "prepared" in a laboratory and then stored systematically, either by taxonomic hierarchy, locality, stratigraphic height, or a combination of all of these. Much of this is analogous to natural historians dealing with modern biotas, and many of the principles associated with their collection and conservation are similar. Early paleontology collections in NPS were primitive, not unlike the current status of many neobiological collections, but paleontology curation has evolved.

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Pre-1980 NPS paleontology collections were often poorly documented and catalogued, the quality varying in direct proportion to the educational background of the collections manager. Amusing if grotesque misidentifications, collections more closely resembling curio cabinets than scientific compilations, and inappropriate methods were scattered in many park units—when fossils were collected at all. Separate categories for paleontological data were not furnished on Servicewide catalog cards; thus many of the fields were nonsensical. This was not particularly remarkable in that there was only one paleontologist in NPS at that time, but such explanations cannot be justifications. Paleontology simply was not a Servicewide priority.

Today, paleontological collections at many parks are vastly improved. Careful curation of correctly identified materials permits subsequent analyses and anticipates research questions. Fields specifically designed for paleontologists have been integrated into the Automated National Catalog System (ANCS+) software. Curators from major national repositories are satisfied with the system they observe in many park units. Unlike neobiology, the reluctance of visiting scholars to deposit important specimens in isolated park museum collections is fading, with the realization that in many cases the park collections *are* the major centers for study of certain kinds of materials, particularly in fields such as biostratigraphy and taphonomy.

What kinds of lessons have NPS paleontological curators learned "along the way" that may prove useful for neontological curators? One is an honest recognition of the limitations of any "blanket" curatorial system. If knowledgeable workers thoroughly curate material in adherence to discipline standards, and afterwards comply with Servicewide methods, one avoids a disservice to the science. Another lesson is to analyze a number of widespread assertions. Due to space limitations, only four of these statements are discussed below; which may be considered as "true or false" questions:

1. Natural history data do not fit into "mandatory" NPS catalog database fields.
2. Cultural and natural history museum "mindsets" are completely incompatible.
3. NPS curators often aren't scientists.
4. "Your museum or mine" is a good question.

Natural history data do not fit into the NPS mandatory software?

This assertion is partially true. For example, most taphonomic data cannot be queried via ANCS+, nor is it straightforward to retrieve critical temporal and stratigraphic information. Many neobiologists and geologists have similar concerns, as well. Part of this problem is the software itself: like many proprietary data products, it was out of date before it shipped—and it shipped a very long time ago, as software half-lives go. The contracted software relies on an archaic engine and the non-intuitive interface is troublesome for those versed in graphic user interface (GUI) databases that use standard pull-down menus. The architects of this scheme certainly meant well. But should NPS be contracting out nearly all of its curatorial data management instead of building its own expertise?

One major problem with databases such as ANCS+ is that they are a "Procrustean bed" for data: the material must be stretched or shrunk, forced to fit the cataloguing structure, often to the detriment of the information and to retrieval of scientifically meaningful patterns. Natural history collections data need to be fluid, like a liquid: able to conform to the parameters of the inquiry, to flow from one kind of analytical software to another, and be available for sharing in a standard format. Rigid data tables "freeze" the data, casting the information into molds designed for other things. Information that cannot fit these molds is lost or misshapen. For example, natural historians urged that Universal Transverse Mercator (UTM) fields be incorporated into the system and links prepared for integration with geographic information systems (GIS) software; neither was. Paleontologists limit the data placed into the ANCS+ to the minimum, adapting other software to their needs.

Despite these criticisms, natural history data can conform with a Servicewide standard platform: with a small amount of planning, data can be imported and exported. All that is required is for the scientist to prepare the information in the software most applicable to the data, then upload this information to ANCS+ for the onerous, but necessary, accountability software.

The assertion, then, is largely false. The real problem is more a lack of computer "savvy," perhaps, and a lack of thorough training in the use of the mandatory software and what it can do—after the more rigorous needs of the science are met.

Are cultural and natural history mindsets incompatible?

At first, this assertion appears to be largely true, as well. The problem might lie in the terms themselves, and the baggage that goes along with them. The real issue is whether or not s*cientific* and cultural mindsets are incompatible; after all, most natural history assemblages have *both* scientific and cultural information in them. Indeed, all human-made collections *are* cultural: once removed from the natural setting, the introduction of collecting biases places the human stamp on the material, like it or not.

Natural history collections actually give us a sense of the "culture of the discipline," glimpses of the *a priori* biases in vogue at the time of the collecting event, and a window on early hypotheses. The collections reflect the paradigms of the times. Many "famous concepts," such as early examples of organic evolution found in the fossil record, were buttressed by museum objects.

Paleontology constantly blends natural and cultural aspects in the pursuit of science. For example, the analysis of a new specimen relies on examination of the original type material. For a taxon of nimravid (a carnivore distantly related to felids), the specimens are housed at the American Museum of Natural History (AMNH), collected 130 years ago from what is now a unit of the National Park System (see Figure 59.1). The original manuscript describing this material (see Figure 59.2) is housed in NPS collections, as a cultural artifact, and these texts and figures must be consulted. A cast of the original material was made by NPS, and both the mold and the resulting casts are catalogued (see Figure 59.3). These casts are manufactured, and thus by definition are artifacts; yet they clearly belong in the natural history category of specimens. All of these kinds of materials are necessary for preparing the peer-reviewed publication describing the new species (see Figure 59.4) collected by NPS.

Thus, one can see that there is a gradation of categories from natural history to cultural objects that are employed by practicing scientists using museum collections. It requires scientists to really appreciate these specimens and use them, but the scientific curators are required to preserve the material, anticipating questions that haven't been asked yet. Note: it is far easier to train a scientist to be a curator than vice versa—which leads us to our next assertion.

NPS curators often aren't scientists?

This statement is absolutely true, and the source of many of the problems experienced by both the National Park Service and outside investigators wishing to pursue scientific problems in the parks. NPS simply must acquire more scientists trained in dealing with natural history collections. Scientific museum collections should be housed where the scientific community can access them. On the other hand, most scientists know that they must travel to where significant collections are. Practicing paleontologists have long been accustomed to traveling to many different repositories to study material. Parks are among those collection destinations these days, and the relatively new influx of professional paleontologists to the ranks of NPS has been a very good trend for the resources *and* the scientific community. That only 1.5% of the NPS museum collections are "natural history" is a sad artifact of cultural bias in the program, not a reflection of the desired state of affairs.

Figure 59.1. Nimravid specimen housed at the American Museum of Natural History.

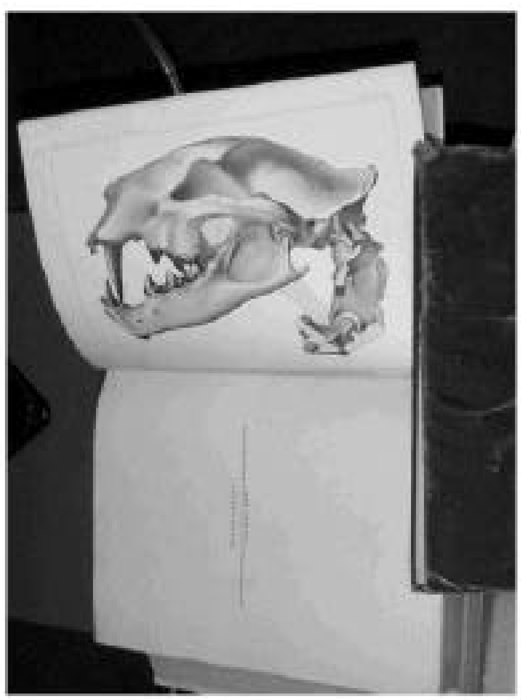

Figure 59.2. The original manuscript describing the nimravid specimen is itself a cultural artifact.

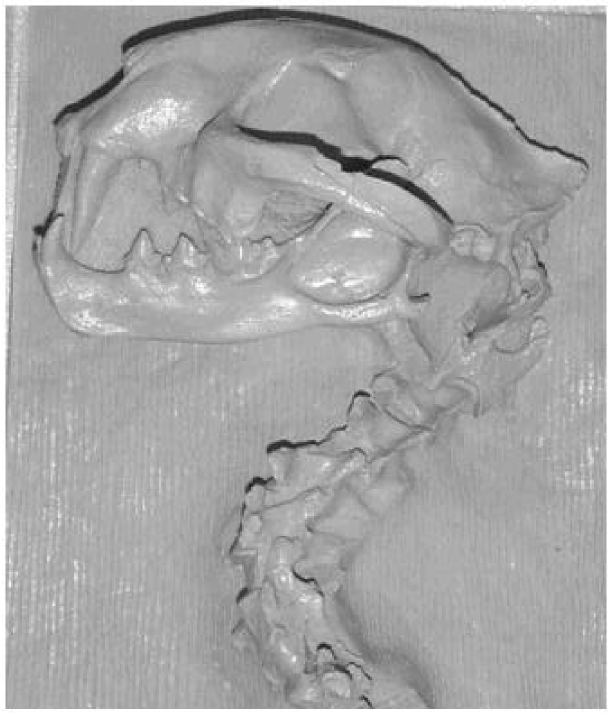

Figure 59.3. A cast of the original material, made by NPS.

Figure 59.4. All of these kinds of materials are necessary for preparing the peer-reviewed publication describing the new species.

Your museum or mine: good question?

Storage regulations should reflect what is beneficial to the resource, and NPS staff must avoid compromising storage situations simply because some naïve law prescribes it. If regulations are causing harm, they must be changed; and efforts are underway to undo some of the more arcane and inflexible regulations that have resulted in castigation of NPS by natural history museum professionals. It seems intuitively obvious that collections of type specimens should be housed where they will be available for the most taxonomists; resource management-related collections stored and available near the resource; and material collected for particular kinds of analyses housed near the analytical laboratory that performs the work. One of the contributions paleontology can make to resolving this dilemma has to do with storage methodologies, and the relevance of a particular kind of collection to a particular kind of museum.

Paleoecologists prefer material organized principally by locality. Taxonomists prefer to work with collections stored by systematic hierarchy. Biostratigraphers favor material organized by temporal units. Examples of such divergent schemes include the collections at the AMNH, where material is stored taxonomically, versus the assemblages at the University of California at Berkeley, where specimens are arranged by land mammal age, then by geographic locality. These decisions were made early in these institution's histories and reflect the curator's biases at the time. It seems intuitively obvious that collections made on behalf of NPS for use by resource management-oriented scientists be deposited within professional facilities established at that park. Lacking such a facility or staff, however, mandates that the collection be deposited elsewhere.

Many of the storage problems stem from decisions being made in a vacuum, without input from museum professionals outside NPS. While recognizing that they are understandably more concerned about their own facilities than the mission of NPS, without the involvement of these people there will not be any commitment to NPS procedures and policies or a desired future museum situation.

Conclusions

NPS paleontologists realized that the lack of Servicewide museum guidance relevant to the discipline had to be solved independently. Relative to the four "true or false" questions, these actions were taken:

1. Data platforms were developed appropriate to the science, information was put into them, and then exported into Servicewide platforms.
2. The value and quality of the "culture" of the science was integrated with the "natural history" aspects of paleontology collections.
3. A critical mass of paleontologists was established at key parks. These staffing solutions were a much more viable and effective means of dealing with the resource than simply contracting with outside consultants.
4. Working relationships with other repositories were developed so that paleontologists could enjoy "the best of both worlds," both at major national museums and NPS collections, some of which are the finest of their kind.

I recommend the same approach for neobiology collections. Appreciation and increases in the value of natural history collections may result in the "nation's leading conservation agency" actually leading museum-based conservation efforts.

Additional suggestions

1. Increase science-based curators at *all* levels of NPS: at the parks, in the regions, and in the Curatorial Services Division. Each region would benefit from having two regional curators providing guidance to the parks and their partners: a culturally attuned professional, as they all are now, and a natural history regional

curator with expertise in one of the major scientific categories: biology, geology, or paleontology.

2. The little-known Museum Management Program Council has an important role in shaping the programs and policies of the NPS museum effort. Currently there aren't any professional scientists represented. The council should seek a professional botanist, geologist, zoologist, and a paleontologist.
3. Cooperative Park Study Units (CPSUs)were a very valuable group of institutions that helped parks study resources of all kinds. NPS could establish a series of Cooperative Park Museum Units (CPMUs) that would ameliorate difficulties parks are currently facing with storage and scholarly examination of natural history collections. By "endowing a curator" at an institution such as a university museum, NPS would have a professional staff member to assure the appropriate care and accountability of NPS museum objects, thus alleviating many of the justifiable concerns these institutions have about loan conditions. In turn, NPS collections would have the benefit of a variety of specialists to examine and properly advise on the care of the tremendous variability of collections. A central repository could house many of the natural history collections and provide a valuable service to both NPS and the natural resource professional community.

60 The nexus of science and protected area policy making: a case study of Russian scientists, national parks, and zapovedniks, 1970-2000

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Introduction

The Russian scientific community has a century-long tradition of criticizing government protected area policies and voicing those criticisms through (relatively) independent societies. Their ability to criticize the government relied on access to scientific data and their standing in society. Events in the late 1980s radically changed the social and political climate of Russia. The scientific community was a small seed of civil society that grew with *perestroika* and combined with the environmental movement to fuel the fall of the USSR. The purpose of this presentation is to report on how the transition of post-Communist Russia is affecting scientists who work in protected area science and policy.

Since 1900, scientists in Russia have resisted the conversion of natural areas into production or agriculture. They established a system of *zapovedniks* (strict nature preserves), defined as areas that exclude virtually all anthropogenic disturbances to preserve typical and unique ecosystems for baseline field research (Weiner 1988; Shtil'mark 1996; Weiner 1999). The national park system was established in the 1970s and protects natural areas while providing for recreational activities. Although scientists still play an important role in protected area policy, their role appears to have changed. Evidence suggests that a significant number of scientists are moving out of academia and into Russian or international non-government organizations (NGOs) to continue to (1) affect policy through early and frequent participation, (2) gain access to government officials, and (3) act as checks and balances on government decisions—three variable but essential aspects to a successful democracy (Schmitter and Karl 1991).

I investigated these fundamental questions:

- Are Russian scientists working with the same institutions or agencies as they were before the fall of the Soviet Union in 1991?
- What is the amount of influence that scientists have on natural resource policy decisions? How does it compare with that in the Soviet era, and what is the trend for the future?

Methodology

Utilizing case study methodology (GAO 1990; Yin 1994), this analysis relies on elite interviews with over forty individuals, including NGO policy consultants, academicians from five state universities, the head of a Zapovednik Directors Association, and administrators in both the Department of Zapovedniks and the Department of National Parks. In addition, small group discussions, roundtable meetings, and written responses from over 70 protected area scientists provides a broad profile. My sample was drawn from the conservation community in Moscow, the Black-Earth region near Voronezh, and the Central Siberian cities of Barnaul and Gorni-Altaisk. Many meetings were arranged prior to my visit thanks to Nikolai Maleshin, Evgeny

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Soviet-era conditions

During the 1970s and 1980s proponents shifted their view of zapovedniks as sacrosanct, self-contained (or closed) biological systems to a view that they are open, dynamic ecosystems (Wiener 1999). The scientific community had to trend a tight line to maintain the social relevance of zapovedniks while perpetuating research on relatively undisturbed natural systems. Additional efforts supported national parks in the Federal Forest Service to address the social demand for recreational and scenic areas. Rather than lobby decision-makers as in the USA, Russians were constrained by a tightly controlled policy-making process.

The scientific community's influence on environmental policy may be described in two broad categories. One was that scientists approved government projects as proposed, or with slight, "Party-acceptable" modifications. Enormous pressure was brought to bear on scientists who were critical of projects. The pressure took several forms: a reduction of financial support, no approval for research, or suppression (destruction) of an individual's career. In general, input on policy development was rarely sought.

The second category of policy influence was whereby criticism and information from the scientific community contributed to some sort of public sentiment or, in the 1980s, protest. As Yanitsky (1993) illustrates, an important aspect of scientists in the policy process was the very nature of how information was passed on. Scientists understood the grim environmental conditions that provided ample opportunity for criticism (Peterson 1993; Pryde 1995). They passed this information on to their children (who often entered similar fields). The children of the 1970s became the outspoken voices for environmental reform in the late 1980s.

In several cases, a number of individuals within the scientific community spoke out against government projects, first privately and then publicly (Darst 1988). General public protests against water and air pollution, hydroelectric dams, and nuclear power incorporated scientific evidence. These same social dynamics kept the conservation community percolating into the 1990s. In particular, student organizations established in the 1960s were some of the most powerful guardians of nature through the 1980s (Weiner 1999). The resulting protests against the USSR undoubtedly contributed to its collapse (Mirovitskaya 1998).

Change in the 1990s

Russia's state of democracy and climate for public participation are unique. The limited form of democracy in Russia has also been described as a "delegative democracy" (O'Donnell 1994). As a delegative democracy, the regime has free and contested elections but, once elected, the president governs with relatively little input from the general public (Tsygankov 1998). Russia's low level of political rights includes a lack of executive accountability; an emergent, but fragmented presidentialism; powerful, self-serving ministries; a tenuous pluralism; and the short history with open elections. Fundamental problems for civil rights includes state pressure on the media ("pro-government" bias), corruption, crime, human rights violations, and the slow reform of the judicial system (Fish 1995; Biryukov & Sergeyev 1997; Juviler 1998; Freedom House 2000). Nonetheless, "ten years after *perestroika,* Russia is more free and more democratic than it was before" (Sakwa 1996, 377).

Participation is partly dependent on enabling legislation and partly on access to policy-makers through personal connections and social status. The socioeconomic changes and deterioration living conditions have limited scientists' ability to dedicate time and energy to policy issues and making political connections. Despite the guarantee for participation and new, clarifying legislation for protected areas (Ostergren 2001), scientists' access to the policy process varies according to a combination of their proximity to Moscow and their affiliated institution. Scientists have become just one more interest group.

Results and discussion

This investigation revealed that conservation scientists fell into three groups: (1) those at the Russian Academy of Sciences (RAS) and ministerial-level research institutes, (2) academicians at state universities, and (3) field scientists in nature preserves and national parks. Scientists who have experienced the most dramatic effect on their careers from the fall of the Soviet Union were (or still are) working with RAS and the research institutes (e.g., agriculture, forestry). In the words of one interviewee, “[t]he system collapsed when the government decided that there was little practical return for the investment in theoretical research. Structured as it was, the RAS simply couldn’t last” (Shvarts 2000). The devaluation of the ruble, inflation, and a general lack of interest in theoretical science has eroded nearly all government funding. Many scientists retain their affiliation with the RAS but rely on a wide range of outside sources for their income. They teach in universities, tutor, work side jobs outside their profession, land occasional grants, consult with NGOs, consult on the rare government contract, or make connections with international universities and organizations.

In terms of a change in career, the Russian scientists who seemed least affected by the fall are those affiliated with the state university system. They have economic difficulties, but the low, steady salaries provide a foundation easily augmented by other activities. The more successful scientists work as teams, either to perform regional environmental assessments or pursue grants from international funds. Research funds generally are applied to infrastructure: computers, copiers, phone lines, e-mail, and research equipment. Although funds are tight, researchers are pleased with the new freedom to choose their own research agenda rather than have it dictated by political authorities. The greatest concern for academicians is that fewer students are opting for advanced degrees and many promising students are avoiding a career in academia. It appears that academia has less prestige and, implicitly, diminished political clout.

The third “group” of scientists are those who work in the field in national parks and zapovedniks. After the fall of the USSR, the cadre of investigators in zapovedniks found themselves in a very difficult situation. Since 1992, funding for preserves across the nation has dropped a catastrophic 60-80% (Ostergren 1998). However, zapovednik communities offered a safe place to live, schools for the children, and enough land space to squeeze out a living. These factors kept many scientists in zapovedniks pursuing research with less and less funding. Since the fall of the USSR their ability to collect data on natural resources has been compromised.

Just as in the state universities, a tremendous concern for senior scientists is the lack of new, young researchers coming to the zapovedniks. The perception is that life is hard with little opportunity for a satisfactory salary. Young people no longer see the benefits or status that accompanied conservation scientists during the Soviet era.

Participation

The most prominent message from all of the respondents was that, technically, the opportunity to influence policy has improved since the Soviet era. However, the means for collecting information to make recommendations has diminished to a level whereby an accurate assessment of conditions is very difficult, if not impossible. The transition to democracy provided the freedom to voice an opinion, but the transition to a market economy constrained the financial resources to form an opinion.

The majority of interviewees characterized scientific influence on policy after 1995 as being less than during *perestroika*. Paradoxically, most recent natural resources legislation explicitly mandates public participation. In fact, 1995 represents a watershed year with the publication of the Law on Specially Protected Natural

Areas—an organic act after 100 years of conservation. The law clarifies the role of protected area personnel, empowers managers to enforce regulations, provides a standing to sue on behalf of protected areas, and stipulates participation in the policy process (Ostergren 2001). Nonetheless, outside of Moscow interviewees felt they have little or no influence on federal policy. Those in Moscow felt as if their influence on policy was marginal at best. The most optimistic group in the sample worked with NGOs whose specific purpose was to influence state policy.

An important avenue for scientists to access the policy process is the *expertiza* (an environmental impact statement). Scientists may be investigators in one of two *expertiza:* one is sponsored and organized by the state, the other, by citizen organizations. The *expertiza* must consider factors such as economic costs and benefits, environmental damage, cultural values, recreational values, and biodiversity. Unfortunately, politicians are demonstrating a general disregard for academics and remain unmotivated to incorporate the results of scientific investigations into policy.

Another political limitation is that scientists rely on the ministries and government agencies for funding. These ministries may be the source of an environmentally questionable project and a scientist criticizing a ministry's project runs the risk of losing future financial support. Still, advocates for conservation wish that more scientists would take advantage of the "new" political climate and speak out on environmental issues. Even with limited information, the scientific community can make powerful recommendations to slow or stop projects until further data is collected.

In contrast to federal policy, academicians and zapovednik scientists reported an increased role in local environmental policy. Professors who serve on local committees may instigate investigations to monitor water or air quality. Additionally, several individuals actively sought consulting positions for businesses expanding their operations. The ideal future would see businesses hiring teams of scientists for advice on how to meet evolving environmental regulations. Several interviewees suggested that consultation would increase the role of scientist in the implementation of policy as well as add to their credibility and stature in the community.

A new strategy, environmental education, takes a long-term view of policy influence. A difference between the Soviet and post-Soviet educators (scientists) is that the goal evolved from creating a basic awareness of flora and fauna to encouraging children to investigate human impacts on the environment and the long-term consequences of utilizing natural resources. A possible long-term benefit is developing a sympathetic political constituency.

The most interesting development is not in the zapovednik employees' ability to create policy, but in their flexibility to interpret policy. As funds from various sources augment federal support, allocation priorities change. New debates have emerged on how to allocate money, time, and personnel. Three general implementation strategies have emerged:

1. Continue conducting research on traditional topics in a traditional format restricting all access.
2. Place the zapovednik in a larger context and conduct research that addresses local or regional community concerns (e.g., game population studies or air quality monitoring).
3. Generate public support through an aggressive environmental education program and allow limited access.

The remarkable change in policy implementation is not in the variety of strategies, but that each zapovednik is *deciding for itself*, on its own, which path to adopt.

Conclusion

As a final challenge to the scientific community, President Vladimir Putin abolished the State Committee on the Environment in May 2000 (the U.S. equivalent is the Environmental Protection Agency). The committee was the umbrella organization for zapovedniks. In addition, he abolished the Federal Forestry Department. Zapovedniks and national parks have been united under one department and placed in the Ministry of Natural Resources—a traditionally utilitarian ministry. It is too early to predict how this will effect the ability of conservation scientists to influence protected area policy, but the outlook is not positive.

Although scientists from universities have less influence on federal policy than during *perestroika*, on the local and regional level they participate through committee work and as advisors. In zapovedniks the change is not how they influence policy creation, but rather how they are interpreting policy and influencing policy implementation. The newfound freedoms are also being tested and exercised in zapovedniks, but often the poor economy restrains the most ambitious plans to conduct research and implement outreach environmental education programs.

The process of democratization is having a mixed effect on participation by the scientific community. The scientific community has freedom to move, freedom to choose a research agenda, and a legal mandate for participation. However, economic survival comes first and they are unable to secure funds to conduct research to support one opinion or another. In that sense, Russia is less democratic than in 1992. In a perfect world, scientists would have ample government support to pursue basic research, while sponsored investigations would influence local, regional, and federal policy to protect and conserve Russia's natural resources.

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61 The National Park Service natural resources management trainee program: 20 years later—looking back to the future

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Introduction and background

Fundamental conflicts between visitor use and resource preservation have been at the core of the National Park Service (NPS) mission (Sellars 1997, 1-5). The public perception of park resources for utilitarian purposes, coupled with the struggle to secure adequate funding for resource preservation (Clarke and McCool 1985, 48-64), have been a paradox for sound, long-term management. As a result, understanding and managing the ecological systems within the National Park System has long proven a difficult task for the NPS. Despite at least a dozen reviews urging change in how these programs are managed, science in the support of ecosystem management has languished in NPS (National Research Council 1992). Until the status of natural resources within NPS was clearly articulated in the second State of the Parks Report (NPS 1981), having park staff dedicated to manage natural resources was more the exception than the rule. In most cases, the responsibility for natural resource management was assigned to park rangers who had a variety of duties; thus, natural resources management was often a collateral responsibility. In a sweeping attempt to rectify that situation, several initiatives were implemented by NPS in the early 1980s (NPS 1981), one of which was the natural resources management trainee (NRMT) program. The program trained personnel in a variety of natural resource-related disciplines with the intent to produce a cadre of natural resource managers to work in individual park units. From a regional prototype in the late 1970s, the NRMT program evolved to a nationwide effort in 1982 (Supernaugh 1994). Twelve years and six classes later, the program had trained nearly 150 individuals dedicated to the management of natural resources throughout the National Park System.

The program's immediate goal was to provide a cadre of natural resource managers working within NPS units (Wauer 1980). At the outset, the long-term impact that these individuals might have on the system was uncertain. How graduates would advance and influence the overall management of park resources was unknown because a career ladder for natural resource managers was not available in NPS. In addition, programmatic initiatives are often short-lived due to a variety of factors, including changing politics, shrinking budgets, and agency

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reorganizations. Finally, the culture of NPS revolves around the park ranger. The NRMT program was designed to produce professional natural resource managers, with the intention that they be classified in the biological science (i.e., 400) series according to U.S. Office of Personnel Management guidelines. Separation of responsibilities for natural resources from the park ranger series represented a fundamental change in how NPS would conduct natural resources management. How this change would be received was unknown. Until a retrospective evaluation could be undertaken, the fate of program participants and an assessment of their accomplishments would remain a question mark.

Nearly 20 years have passed since the first NRMT program was implemented, and we attempted to evaluate the success of the program, albeit somewhat subjectively, by examining where program participants had moved to in their careers and what type of work they have been engaged in. Our objectives were to determine if these individuals had moved into senior-level positions and, if so, were they having a significant, positive impact on natural resources throughout the National Park System.

Methods

We conducted telephone interviews in the spring of 2001 with individuals from all six NRMT program classes to determine their current occupational series and grade, and to develop some perspective about the success and shortcomings of the program. Individuals were also questioned about what they felt was their most significant contribution to the natural resource arena. We synthesized the administrative details of the program and briefly discuss how changes in the structure of the NPS affected the program.

If individuals had left NPS but were still in the federal service, we included their personnel information in our database. We compared federal grade and occupational series data with identical information collected nearly 10 years earlier (1992) after the completion of the fifth class of the NRMT program.

Program synthesis and results

The first class of the NRMT program was 24 months long and included 37 trainees. Subsequent classes were shortened, ranging between 13 and 22 months with a class size of 20-25 individuals. For the first two classes, the positions were encumbered and new position announcements solicited potential candidates. The program later evolved into a format which selected participants based on a training announcement. Employees were then selected based on their qualifications, coupled with park needs.

We contacted 120 out of a possible 147 individuals that participated in the program. Ninety-four percent (n=112) of the individuals that were interviewed still work for NPS. Ninety-six percent work in the Department of the Interior. Eighty-six percent of the first class completed the training and graduated from the program. All 110 participants who entered the last five classes completed the program. Participants have proceeded to fill positions at all levels of management within NPS (Figure 61.1). Federal grade levels, as expected, have increased over time. One participant from the first class is now in the Senior Executive Service (SES) training program.

Individuals currently hold positions in eight different U.S. Office of Personnel Management occupational series (Figure 61.2). There has been a slight decrease in the number of park ranger positions in the 025 occupational series since the program started despite the fact that 12 individuals are now park superintendents. Since the program's inception, most individuals have been employed as biologists or natural resources specialists (series 401), but positions now reflect a greater number of categories within the biological science group (which includes all 400 series). Some individuals also have moved to positions within the administrative group (300 series), demonstrating a broad range of administrative and program management responsibilities.

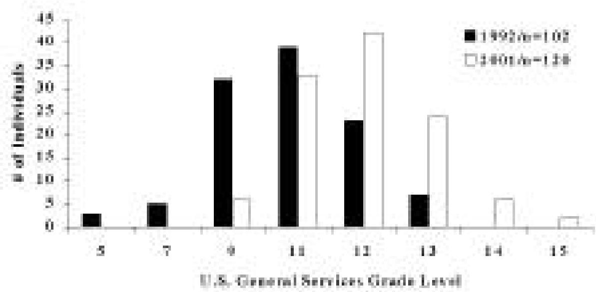

Figure 61.1. Federal grade levels for participants in the natural resources management training program in 1992 and in 2001. As of 1992, only five classes had been completed.

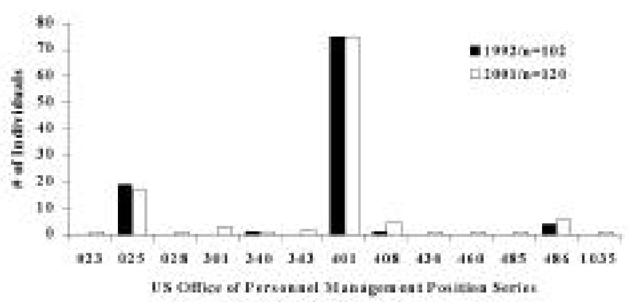

Figure 61.2. Occupational position series for participants in the natural resource management training program. As of 1992, only five classes had been completed. Position series are as follows: 023 – environmental specialist; 025 – park ranger; 028 – environmental protection specialist; 301 – administrative technician; 340 – program manager; 343 – manager; 401 – biologist; 408 – ecologist; 430 – botanist; 460 – forester; 485 – refuge manager; 486 – wildlife biologist; 1035 – public information specialist.

Discussion

Nearly 20 years have elapsed since the NRMT program began. Although the original goal of the program was to train individuals to manage a park's natural resources (Wauer 1980), there has been a widely held conviction that people graduating form this program would eventually become senior managers in NPS. Within NPS, one measure of success—and a route of entry into senior-level management—is to become a park superintendent. Representing slightly more than 8% of all program participants, superintendents now manage sites that range from the largest natural areas to small historical and urban NPS units. Program graduates also manage sites in the Bureau of Land Management and the U.S. Fish and Wildlife Service.

Because program participants chose to focus on a career in natural resources, it seems reasonable that not all these individuals would aspire to become park superintendents. Many individuals from this program have continued to focus their careers in natural resources management and hold key NPS natural resource positions as program chiefs in individual parks, regions, and at the Washington level. A classic example of the influence by program participants is demonstrated by the fact that some NRMT graduates have been instrumental in establishing a career ladder for natural resources management in NPS.

Despite funding shifts and administrative reorganizations within the NPS Division of Natural Resources, the NRMT program managed to survive 12 years. As with any program, there were both positive and negative aspects (Table 61.1). Of those we interviewed that have left NPS to work for other federal agencies, particularly those in the Department of the Interior, there was a perspective that NPS was somewhat archaic in their approach to natural resources management. These individuals felt that natural resources were not considered a priority and on a level equivalent with other NPS operations.

Strengths

- Exposure to a diversity of issues and disciplines
- Network of contacts
- Understanding of agency culture and mission

Weaknesses

- One training curriculum fits all participants
- Too much time and travel
- Training responsibilities versus position duties
- Lack of training in cultural resources

Table 61.1. Strengths and weaknesses of NRMT program as perceived by participants.

There is some sentiment in NPS that the NRMT program, despite its relatively long tenure, was stopped prematurely. Another perspective is that NPS must develop more of an institutional memory regarding the management of natural resources (M. Soukup, NPS associate director for natural resources, personal communication). These ideas are not mutually exclusive, however, and we believe that the NRMT program, by providing natural resource managers to areas without such historic expertise, does in fact provide an institutional memory, or at least the beginning of one. We also believe that the projects and issues (Table 61.2) that

NRMT program participants have managed or influenced is a clear testament demonstrating the significant positive impact of this program on NPS. Some of these projects are still in progress and will continue to have a long-term positive influence on natural resources management across NPS. It seems clear that the initial goal of the program to produce a cadre of natural resource managers in parks was met and perhaps has been exceeded with the entry of an ever-increasing number of program graduates into the ranks of NPS senior management.

- Designation of Dry Tortugas as a Natural Area Reserve
- Dam removal adjacent to Olympic National Park
- Carrying capacity model for Mount Rainier National Park
- Parkwide faunal and floral inventories: Great Smoky Mountains National Park, Valley Forge National Historical Park, Channel Islands National Park
- Resource stewardship curriculum for NPS protection rangers
- California Desert Protection Act
- Endangered species protection and population viability: grizzly bears, gray wolves, ruffed grouse, elk, sea turtles
- Exotic species removal: mountain goats, oryx, exotic plants
- Ecosystem restoration: reptile and amphibian populations, riparian habitat, wetlands
- National natural resource information database

Table 61.2. Natural resource projects and issues in which NRMT participants have been involved.

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62 Great Sand Dunes eolian system archaeological program research through multiple disciplines and multiple partners

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In a pocket on the eastern side of southern Colorado's San Luis Valley sit the Great Sand Dunes, the continent's tallest dunes. These dunes, developed by winds blowing across the valley, are textbook examples of reversing dunes and are the most conspicuous portions of a greater eolian system. The system is complex, containing many varied elements: the dunes themselves, inter-dunal wetlands, sand sheets that feed sand to the dunes, the sabkha (the crusted and mineralized surface of ancestral lakebeds), and the creeks that originate in the Sangre de Cristo Mountains to the east and flow past the dunefield, transporting sand upwind into the system (Figure 62.1).

Until fall 2000, Great Sand Dunes National Monument contained primarily the dunes themselves and little else. The need to protect the complete eolian system was strong. On November 22, 2000, President Bill Clinton signed legislation that allows for the creation of Great Sand Dunes National Park and Preserve, whose new authorized boundary includes most of the relevant eolian system. This expansion includes the headwaters of Medano and Sand creeks within 41,646 acres of national preserve and an additional 107,000 acres of sandsheet and sabkha to the west and northwest. As of this writing, designation as a national park is pending acquisition of these 107,000 acres. The current designation is "Great Sand Dunes National Monument and Preserve."

Interwoven with the natural environment is a very long and rich human history, dating from the Clovis around 11,200 years ago and the Folsom around 10,500 years ago. Investigations into cultural resources were identified as a high priority in the park's resources management strategy, which became the impetus for the Great Sand Dunes eolian system archaeological program.

Program background

In fiscal year 2000, the park received initial funding for a multi-year archaeological inventory program. Additional monies were also received to investigate unspecified areas on The Nature Conservancy lands just outside the park. At a well-attended public scoping session, three things became evident:

- Any high-quality archaeological program would have to be much larger than the park's boundaries;
- There was insufficient money, even to address pure inventory needs in the park and
- A great variety of specialists would be required.

From **Crossing Boundaries in Park Management: Proceedings of the 11th Conference on Research and Resource Management in Parks and on Public Lands,** edited by David Harmon (Hancock, Michigan: The George Wright Society, 2001).

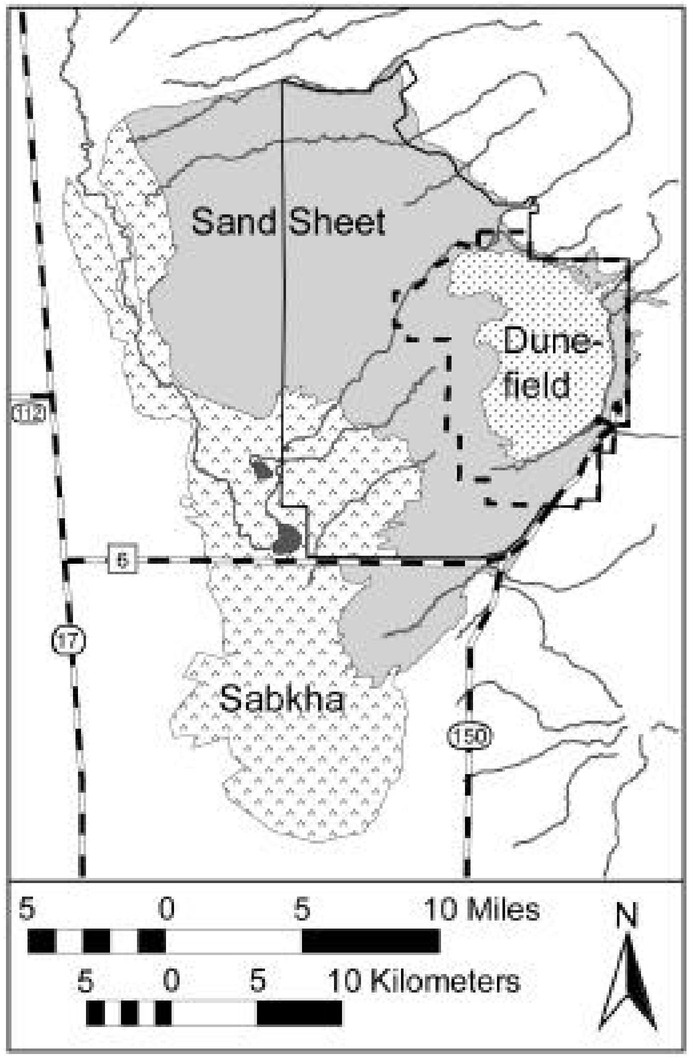

Figure 62.1. Principal eolian features of Great Sand Dunes National Monument and Preserve.

During the scoping session, several integral components of the program were identified:

- Use of a geochronological framework as a basis for interpreting the archaeological sites and other features;
- Cultural anthropological investigations into historic and ongoing traditional use of the dunes;
- Specialized studies of all types, ranging from trace element analyses of lithic raw materials to investigations of population movements to characterization of diatomaceous stratigraphic units as a means to study past environments;
- A variety of archaeological specialties;

- An education component for both schoolchildren and the general public; and
- A volunteer component, particularly due to the high degree of archaeological interest in the San Luis Valley and the qualifications of the San Luis Valley Archaeological Network's members.

To accomplish the project, a consortium of organizations, institutions, and individuals was formed, with each entity providing what it can to facilitate the overall program. The participants include:

- Foothill Engineering, Inc.;
- Applied Cultural Dynamics;
- The Nature Conservancy;
- San Luis Valley Archaeological Network;
- U.S. Geological Survey;
- Smithsonian Institution;
- U.S. Forest Service Passport in Time Program;
- San Luis Lakes State Park;
- The Friends of the Dunes;
- National Park Service (NPS), Great Sand Dunes National Monument and Preserve and the NPS Intermountain Support Office—Denver; and
- Colorado State Historical Society, Office of the State Archeologist.

With matching funds from NPS, The Friends of the Dunes received two substantial grants from the Colorado State Historical Fund. Additional funding was received from the Department of the Interior's Burned Area Emergency Rehabilitation (BAER) fund to redocument and evaluate documented archaeological sites burned in an April 2000 wildfire.

Background

An important starting point for the inventory was *Colorado Prehistory: A Context for the Rio Grande Basin*, a recently published study of the region's human history. This document makes it clear that archaeological understanding of the San Luis Valley is extremely limited. In fact, the prehistory of the region is practically unstudied and paleoenvironmental information is minimal. There are a number of compliance-driven inventories that document the use of chipped-stone tools used throughout the valley. There are many poorly provenienced collections. But very few sites have been tested and even fewer excavated. Scant contextual information exists, and there are only a handful of radiocarbon dates. As a result, chronological information is rudimentary at best. The Paleo-Indian period is the most known and best-dated, mainly because of the Smithsonian Institution's past research. We know there is a generic "Archaic" period, and we know, through ceramics, that there are Late Prehistoric sites.

Due to the lack of excavation data, there are few in-context associations. There are few assemblage data, so we don't know, for example, what late Archaic "looks" like. Hearth styles cannot be associated with any group or time period, other than by comparison to other parts of the country. Similarly, subsistence information is minimal. Very few hearths have been collected, and other than Paleo-Indian, no floors or other living surfaces have been rigorously investigated. There are some extremely large, bizarre stone tools that appear to be pestles of some type, but none have acceptable provenience or associations. We can only guess about the grasses, other plants, and animals that sustained the lives of the prehistoric occupants of the eolian system.

To address many of these information gaps, geomorphological, ethnographic, and archaeological research was begun in summer 2000. In only one field season, the researchers have compiled a tremendous amount of information.

Geomorphology

The Quaternary history of the Great Sand Dunes area is not well known, mainly because wind erosion has erased much of the evidence commonly used to distinguish deposits of different ages. Nevertheless, several kinds of evidence remain that provide insights into how and when components of the existing landscape were formed. Materials suitable for C14 dating have been collected along Sand Creek and Big Spring Creek, two streams that have different fluvial histories. Big Spring Creek originates at a spring located in dune sand and its alluvial history is contemporary with a period during which the water table has been near its present level. In contrast, Sand Creek originates in the Sangre de Cristo Range and has gravel terrace deposits, now mostly buried by dune sand, that extend much farther back in time than the sandy terrace deposits of Big Spring Creek. Other sources of geochronological and environmental information include (1) abandoned springs, (2) relict floodplain deposits, (3) paleopond deposits, (4) buried paleosols, (5) zones enriched in secondary CaC03 of both pedogenic and groundwater origin, and (6) a bed of benthic diatoms that records the existence and level of a lake that once existed in an area now covered by dunes. Further research will focus on Medano Creek, which flows to the east and south of the dunes.

Ethnography

Ethnographic overview research on the San Luis Valley demonstrates that both ethnic and functional complexity must be expected in dealing with the protohistoric archaeological remains. In addition to Ute and Jicarilla Apache people, who were present in the valley on a regular seasonal basis, the area was substantially used by northern Pueblo (Tiwa and Tewa), Navajo, and Comanche people as well, and occasionally by Cheyenne, Arapaho, Kiowa, and Klowa Apache people. Summer villages, temporary food-processing sites, and military fortifications are only a few of the types of sites suggested by ethnohistoric research; consultation with contemporary Native Americans shows a variety of other uses of the area, including use of sand from the Great Sand Dunes for ceremonial purposes. Ongoing research will expand the present understanding of present and recent past uses of the eolian system.

Archaeology

The two primary archaeological partners involved in this project are the Smithsonian Institution and Foothill Engineering Consultants, Inc. The Smithsonian work is focused on the western side of the park at Indian Springs and Big Springs. This area contains an incredibly rich concentration of archaeological remains dating from as recent as several hundred years ago to over 10,000 years ago. Prehistoric archaeological findings during the 2000 field season included the first documented house pit structure in the area, possibly dating from 4,000 to 6,000 years ago. The house pit contained subfloor features and several artifacts, including a bone awl and a stone pendant. The Smithsonian research is tied closely to the geomorphological investigations in an attempt to clarify how the geological landscape is related to cultural occupation through time.

A wildfire on April 18, 2000, burned approximately 3,000 acres on the eastern side of the park. The burned area contained 67 documented prehistoric and historic sites. Using BAER funds, Foothill Engineering Consultants archaeologists relocated and evaluated the effects of the fire on these resources. Site documentation was updated and each resource was evaluated for potential listing in the National Register of Historic Places. The impact of the fire on the cultural resources varied significantly. One positive aspect of the fire was that it burned off vegetation that had previously hidden both historic and prehistoric sites. Sites that were once thought to be small in size were oftentimes found to be much larger that originally recorded. The fire also had negative impacts, for it burned the artifacts and features on the surface of the sites. Artifact damage appeared to be minimal, although some of the stone artifacts seemed to be friable after burning. Some historic and prehistoric features were also damaged or destroyed during the fire. For example, a known wickiup (conical poled lodge) was completely burned. It appears that none of the known culturally peeled ponderosa pine trees were damaged by the wildfire.

Preliminary treatment at endangered sites included collection of diagnostic artifacts and testing of prehistoric fire hearths. One of the tested hearths contained over 150 pounds of rocks, an obsidian flake, and a small corner-notched projectile point. C14 dates obtained from four of the hearths in the park (including this rock-filled one) indicate occupation from the Late Prehistoric period, ca. AD 1000. Obsidian artifacts from nine sites (including the flake from the rock-filled feature) were chemically sourced and found to have come from the Jemez Mountains in northern New Mexico, approximately 150 miles to the south. This is important information regarding prehistoric trade and travel routes.

Involvement of partners and the public

Involvement by project partners has been significant. The Friends of the Dunes, a non-profit support group for the park, applied for and received two grants from the Colorado Historical Society worth $260,000. The purpose of these grants is to supplement and support multidisciplinary research team efforts. The first grant-funded work will begin in summer 2001 with several archaeological survey and testing projects and geomorphological investigations.

The Nature Conservancy is another valuable partner that supports the overall archaeological program. Examples of their involvement include hosting team and public meetings, and giving tours of archaeological sites to members and the interested public.

Public education and volunteer opportunities are considered a very important aspect of the overall project. In addition to The Nature Conservancy, several groups are involved in this part of the project.

Passport in Time is a volunteer archaeological program administered by the Forest Service. This year, a Passport in Time project will investigate several sites containing wickiups. These wickiups, located within the newly designated park expansion area, usually date from the late 1700s to the late 1800s. Forest Service and NPS archaeologists and volunteers will also work closely with Native American tribal representatives, such as those from the Ute and Apache, to further our understanding of the wickiups and help determine management strategies for these fragile resources.

Middle school students in the Dig This 2 archaeology class from the St. Vrain Valley School District in Longmont, Colorado, spent several days volunteering with Foothill archaeologists last summer. They assisted with excavation of a hearth and helped record several historic sites. Additional student volunteer sessions are planned for this field season.

Local San Luis Valley schools are also involved in the program. One local middle school student volunteered with the archaeological survey crew for several days last year, and additional interest has been generated for volunteer opportunities for the 2001 season.

The final public entity supporting the program is the San Luis Valley Archaeological Network, a local archaeological advocacy group that is very active in the area. This group will be supporting the program by providing numerous field volunteers this summer.

Conclusion

Work on the Great Sand Dunes eolian system archaeological program has only just started and has already yielded tremendous amounts of information on the human history of the area. With the efforts of specialists from many disciplines and the participation of many diverse partners, this project will provide invaluable insights into the area's rich human history.

63 Crossing park boundaries in the study of ancient ecosystems

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Introduction

National park units have at times been referred to as "ecological islands." More recently, such units have begun to be viewed as ecological mosaics rather than separate island units as managers of publicly owned, federally managed lands have increasingly gained an appreciation for park boundaries and their relationships to particular biological issues. It is often apparent to these managers that individual park boundaries may not fully encompass appropriate habitat areas for managing biological resources. As a result, partnerships have been sought within and between land management agencies to best accommodate the needs of these biological resources.

In order to understand the natural world of today, one must examine the past. Studies such as those discussed below show that fossils are more than oddities of the rock record; they represent the record of life that has evolved on this planet. They are the means to test the scale and robustness of ecological principles observed in the modern world. Given the human proclivity for habitat manipulation, understanding ecological principles in geologic time can only be insightful.

Linking national park units is ideal for providing insights into ancient ecosystems because such units contain some of the most productive fossil-bearing rocks in North America. Traditionally, geologic—and by extension paleontologic—resources have been treated as isolated phenomena. For example, Fossil Butte National Monument contains a remarkably rich sequence of rocks containing some of the most spectacular fossil fish from the Eocene (58 to 36 million years ago) found anywhere in the world. However, this resource is often viewed as unique without regard to how the large fossil lake containing these fish relates to the contemporary environment of its time.

A notable exception is the Morrison Formation ecosystem project, a multi-year ancient ecosystem study sponsored by the National Park Service (NPS), that focused on the Late Jurassic Morrison Formation ecosystem. We briefly summarize basic results from one component of this study focused on the dominant group of vertebrates from the terrestrial ecosystem, the sauropod dinosaurs. This summary of data on sauropods illustrates the advantages of examining fossil resources in context beyond individual park boundaries. Lastly, we suggest an even larger-scale project that would minimally tie together NPS units from near the Arctic Circle (Denali National Park and Preserve and Yukon-Charley Rivers National Preserve) all the way to the Rio Grande Valley (Big Bend National Park). This suggested project is an extension of a crossing boundaries approach to studying ancient ecosystems and illustrates the nearly limitless nature of such an approach.

The Morrison Formation ecosystem project

The Upper Jurassic Morrison Formation of the western USA records a highly unusual time in earth history. At least six different genera of sauropods are recorded from this formation, and more than one taxon is represented at many localities (Dod-

From **Crossing Boundaries in Park Management: Proceedings of the 11th Conference on Research and Resource Management in Parks and on Public Lands,** edited by David Harmon (Hancock, Michigan: The George Wright Society, 2001).

son et al. 1980). The most spectacular locality is the Carnegie Quarry at Dinosaur National Monument, which at one time was recognized as the single most important Jurassic vertebrate fossil site in the world. Sauropods were long-necked, long-tailed animals with adult weights estimated to range from 5 to 80 metric tons (Anderson et al. 1985; Colbert 1962: Colbert 1993) and these animals coincide closely with the popular view of a dinosaur. The most common of these taxa, and the ones most often found in association, are *Camarasaurus*, *Diplodocus*, and *Apatosaurus*. At Carnegie Quarry, it has been shown that this co-occurrence of sauropod taxa probably represents ecological coexistence rather than the mixing of different faunal assemblages as a result of stream depositional processes (Fiorillo 1994). Nowhere today do so many large-bodied animals co-exist in a terrestrial ecosystem.

Partitioning of food resources has been demonstrated for the two most common sympatric sauropod dinosaurs, *Camarasaurus* and *Diplodocus* (Fiorillo 1998). The patterns of occurrence of pits, coarse scratches, and fine scratches on the surfaces of teeth of these taxa show that, in general, *Camarasaurus* ate coarser foods than did *Diplodocus*. In contrast with the majority of *Camarasaurus* teeth belonging to adults, which show evidence of ingestion of coarser foods, the teeth of juveniles show a pattern of wear similar to that observed on *Diplodocus.* This suggests that there was dietary overlap between the young of *Camarasaurus* and adults of *Diplodocus*, and that dietary divergence occurred when individuals of *Camarasaurus* achieved adult size.

During the Jurassic, at the time these two sauropod taxa roamed western North America, there existed an enormous hypersaline, alkaline lake (>150,000 sq km) called Lake T'oo'dichi (Owen et al. 1989; Turner and Fishman 1991). The presence of this environmentally sensitive, large-scale feature provides a unique opportunity to examine the role of climate in the ecology of extinct vertebrates from the Mesozoic. The sites that produced these teeth are of varying distance from ancient Lake T'oo'dichi and extend along an 800-km transect. The site closest to the lake is Dinosaur National Monument and continues northeastward and includes sites extending into eastern Wyoming (Figure 63.1). There appears to be no variability on the wear patterns of these teeth regardless of the locality. This implies that the diets of these large dinosaurs remained unchanged due to the climatic influence that produced the alkaline lake (Fiorillo 1996). The elephant and the giraffe are often used as modern analogues for sauropods, the former because of its body size and the latter because of its long neck (e.g. Colbert 1993). Given comparisons with these modern-day large herbivores, sauropod feeding behavior is more similar to that of giraffes than to elephants because giraffes do not vary their diet due to climatic variance (Owen-Smith 1988).

The above points highlight the value of looking beyond park boundaries for gathering life history data for ancient organisms. Specifically, food partitioning, which in modern ecosystems is a mechanism for co-existence by animals that are similar, was documented for the two most common and dominant animals of the ancient terrestrial ecosystem. Further, dietary change from juveniles to adults was also demonstrated (Fiorillo 1998). Lastly, with respect to environmental response, sauropods behave more similarly to giraffes than to elephants. By moving beyond the boundaries of one park, Dinosaur National Monument, the studies mentioned here illustrate that sauropods were animals living in a diverse and dynamic landscape.

A proposed Western Interior Seaway project

During various times during the Mesozoic Era a shallow seaway extended from the present Gulf of Mexico to the Arctic Ocean (Figure 63.2). Rocks laid down during this time have produced the vast majority of fossil vertebrates from the Mesozoic and include such famous dinosaurs as *Tyrannosaurus* and *Triceratops,* and other such famous fossil reptiles as the swimming mosasaurs and the flying pterosaurs. The Cretaceous is a vitally important time, for it is when many of the modern groups of mammals appear in the fossil record. By the end of this geologic period many organisms, including the reigning dominant terrestrial life forms, the dinosaurs, go extinct. With respect to terrestrial vertebrate biogeography along the Interior Seaway, many animals have a cosmopolitan distribution along its entire length (such as the duck-billed dinosaur, *Edmontosaurus*), while other animals have only localized distributions.

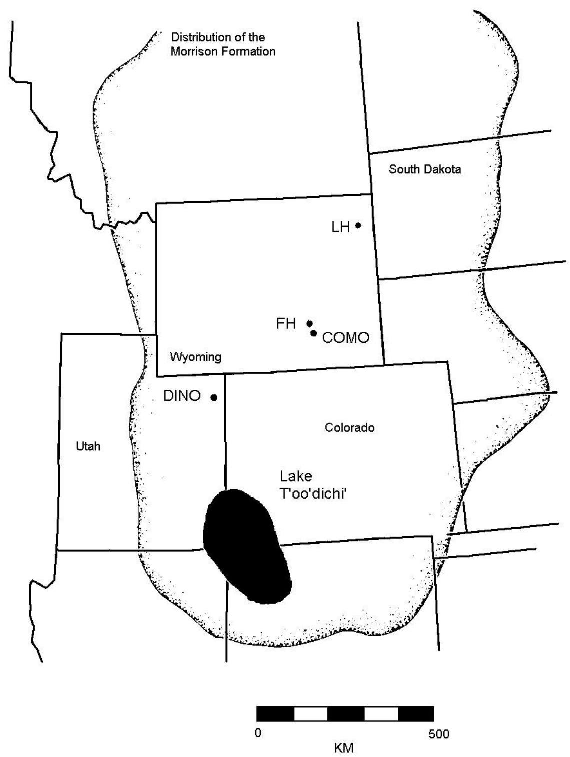

Figure 63.1. Map of the westernmost distribution of the Morrison Formation, also showing the general location of Lake T'oo'dichi and the four localities that yielded sauropod teeth examined in this study. The locality acronyms DINO, FH, COMO, and LH refer to Carnegie Quarry (Dinosaur National Monument), Freezeout Hills Quarry N-O, Quarry I (?) Como Bluff, and Little Houston Quarry, respectively.

As an example of the latter, the last surviving sauropod dinosaur in North America is *Alamosaurus*. The known distribution of *Alamosaurus* is limited to lower latitudes and has only been found as far north as Utah. These animals are perhaps best known from the Late Cretaceous Javelina Formation in Big Bend National Park in western Texas. While in the modern world one can appreciate the reasons why polar bears don't wander around Texas, the reasons for a restricted distribution for *Alamosaurus* are not as apparent.

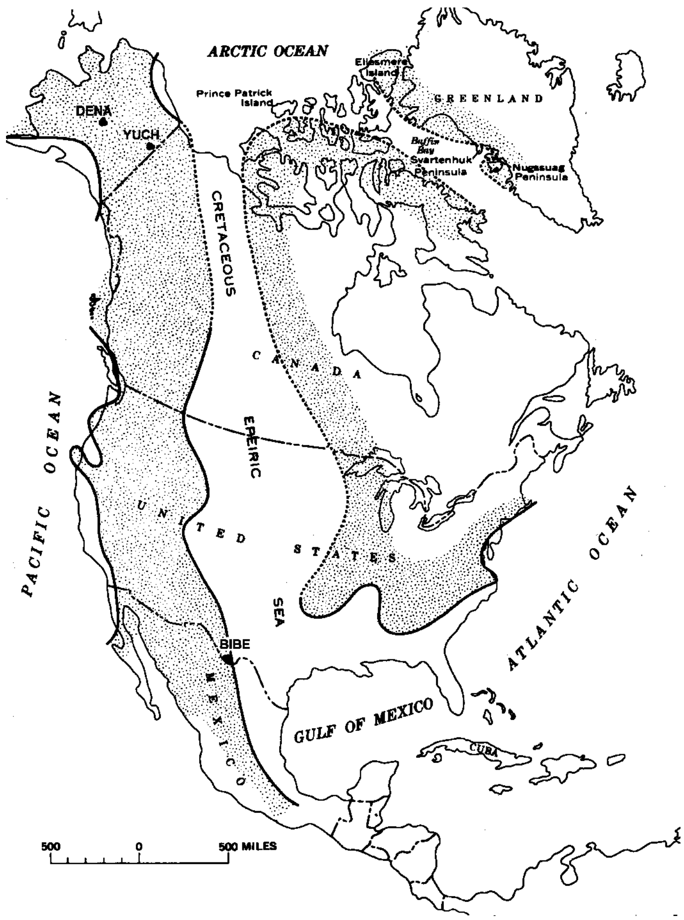

Figure 63.2. Schematic drawing of the Western Interior Seaway of North America during the Cretaceous. Denali National Park and Preserve, Yukon-Charley Rivers National Preserve, and Big Bend National Park are designated respectively by DENA, YUCH, and BIBE. These parks illustrate the range of NPS units that contain rocks deposited during the Cretaceous. Map modified from Gill and Cobban (1973).

By examining the rocks containing sauropods both in the Morrison and the Javelina formations, one can observe a pattern of ancient semi-aridity associated with sauropods (Engelmann et al., in press). Whereas this aridity is evident at the south end of the Interior Seaway, looking beyond the boundaries at Big Bend National Park to the north end of the seaway, the rocks indicate a much moister environment (Engelmann et al., in press). Therefore, one can tentatively attribute the restricted distribution of *Alamosaurus* to regions of aridity.

In still another example of ecological insights to be obtained by expanding beyond park boundaries, a recent study of the distribution of theropod dinosaurs along this seaway has provided insights into ecosystem dynamics for the Cretaceous. This recent study has shown that though many taxa are in common from north to south, there is slightly less diversity at the north end of the seaway compared with the south (Fiorillo and Gangloff 2000). This is a pattern consistent with the distribution of many animals in the modern world and is likely related to resource availability and diversity. In addition, although the theropod dinosaur *Troodon* dominates the northern assemblage, this genus is rare farther south. One characteristic that distinguishes this theropod is the presence of large orbits, a feature in modern animals attributed to an adaptation for low-light conditions. Low-angle light is the condition in high latitudes regardless of geologic time. Thus, it has been suggested that the dominance of *Troodon* is likely a faunal adaptation by this component of a cosmopolitan theropod fauna to low-light conditions at a high paleolatitude (Fiorillo and Gangloff 2000).

These are just two examples of the results that can be obtained from expanding beyond park boundaries in the study of ancient ecosystems. In addition to qualitatively outlining the Western Interior Seaway across North America, Figure 63.2 also shows the position of Big Bend National Park, Denali National Park and Preserve, and Yukon-Charley Rivers National Preserve. These parks all contain sedimentary fossil-bearing rocks of the same age, and serve as end points on a transect along this seaway. Many other national park units, also containing similar-aged rocks, are intermediate in position between these parks.

The above discussion has highlighted the potential for cross-boundary studies. A comprehensive investigation by a team of field, lab, and library researchers and geographic information systems (GIS) specialists investigating the expansive rock sequences of the Cretaceous Western Interior Seaway in these many parks can provide further details in an important ancient ecosystem. For example, it has been suggested that the fluctuations of the seaway exerted speciation pressures on organisms by expanding and contracting niche spaces (Weishampel 1987; Horner et al. 1992). Detailed paleontological investigation linking parks with similar-aged rocks can provide a valuable means for testing models for paleoecology, evolution, and the paleogeographic distribution of ancient taxa.

Summary

Fossils are the basis for understanding life in the past. They provide the means for determining long-term patterns of evolution. They also provide the means for examining how ancient organisms may have interacted among themselves within a community. NPS units contain some of the most important fossil-bearing rocks anywhere in North America. By linking parks with similar-aged rocks to other areas, either within the National Park System or elsewhere, important additional paleoecological insights on specific ecosystems can be obtained. Here we have briefly discussed one component of a successful effort to link similar land units to better understand an ancient ecosystem. Further, we have suggested an additional venue for application of the crossing boundaries approach to understanding ancient ecosystems. While these early efforts have proven valuable, additional large-scale projects are needed to compare ecosystems through time.

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64 Melrose, a multifaceted jewel in the NPS crown: interdisciplinary contributions to historic preservation and museum collection management

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The Melrose estate, a unit of Natchez National Historical Park, provides a case study for National Park Service (NPS) development of a historic house museum site. NPS acquired the 80-acre estate in 1990 to interpret slavery and the antebellum planter class, primarily because of the quality of the resource. Melrose had already received National Historic Landmark designation, with the red brick Greek Revival mansion and outbuildings, grounds, and historic furnishings all cited as contributing elements. An examination of the first decade of NPS stewardship at Melrose shows how management decisions for such museums and their collections must cross boundaries to consider historic structures and landscapes as well as museum objects in planning an effective context for preservation and interpretation. It also shows how cultural resource management must be creative in exploring varied sources to gather information for these decisions, from archives and oral histories to historic photographs, site analysis, and archaeology.

The development of Melrose began in the 1840s, when attorney and planter John T. McMurran constructed a new family home on a roughly 100-acre suburban estate on the eastern edge of Natchez, Mississippi. The property, defined on three sides by deep bayou channels carved into the loess soil, lay fallow as part of a used-up cotton plantation at the time of McMurran's purchase in 1841. In the early 1990s, an exhaustive archival investigation by furnishings curator Carol Petravage of the NPS Harpers Ferry Center, combined with cross-country trips to track down McMurran descendants, turned up a wealth of materials in the form of letters and diaries relating to the McMurran family and their two-decade occupation of the Melrose estate. Some of these materials shed light on resources still remaining at Melrose, such as the great magnolia tree that Mary Louisa McMurran recorded her husband having planted outside their bedroom window. Resources that had been lost over the years were revealed in other letters, such as one written by John McMurran that described in great detail the wooden Venetian blinds he had purchased in Philadelphia for the primary rooms at the Melrose mansion, including the color (French green), and the fact that those purchased for the downstairs rooms had decorative silk tapes sewn onto them.

The museum collections at Natchez National Historical Park contain many objects that can be directly associated with the McMurran family. These include a range of furnishings as well as very personal objects, such as the fine pink and white lace gown from Paris which local oral history maintains was part of the wedding trousseau of the McMurrans' daughter in 1856. A pair of massive walnut bookcases in the Melrose library houses a collection of period books, many with McMurran inscriptions, that help provide insight into the education and mindsets of individual family members. After the death of their daughter and two grandchildren of disease during the Civil War, the McMurrans sold Melrose complete with most of its original furniture. The room-by-room inventory made at that time has assisted NPS curators attempting to determine which of the current Melrose furnishings can be dated to the McMurran era—an act of "inside archaeology" trying to reconstruct accurate layers

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of historical context for the objects. The inventory has provided parameters for the park's scope of collection statement and guidance for the historic furnishings plan, as well as becoming an important artifact itself within the park's museum collection.

Elizabeth and George Malin Davis purchased the Melrose estate from the McMurrans in 1865, after Union soldiers occupied their town home, Choctaw, during the Civil War. Documentation of this occupation has suggested a seed of truth in the local myth of a marble table now at Melrose with a design of inlaid birds whose semiprecious eyes were supposedly plucked out by Yankee soldiers. The childhood death of one Davis daughter, Frances, provided the occasion for a beautiful Victorian funerary portrait also now at Melrose. The 1883 death as a young woman of their other daughter, Julia, left her six-year-old son, George M. D. Kelly, as heir to Melrose, Choctaw, two other Natchez mansions, and vast plantation acreage in the fertile Louisiana bottomlands across the Mississippi River. Young George Kelly left Natchez after his mother's death to be raised by his maternal grandmother in New York, and former Davis family slaves cared for the Melrose estate and its furnishings while the mansion was closed for the remainder of the nineteenth century. Alice Sims and Jane Johnson are remembered as the African-American women who lived with their families in outbuildings on the Melrose estate and served as caretakers during this time. Much information remains to be gathered regarding the Davis-era activities at Melrose because a wealth of associated archival material remains unexplored in private hands at this time.

In 1900 George Kelly married a New York debutante, Ethel Moore Kelly. The following year he brought his bride to Natchez for the first time. They selected Melrose as their primary home, and their efforts to restore the mansion after its years of closure are generally credited as the first historic preservation efforts in the state of Mississippi. Their inherited wealth enabled the Kellys to indulge their passions for traveling and hunting. It allowed them to purchase what is thought to be the first automobile in Natchez. It also permitted them to acquire a series of cameras that recorded invaluable images of the Melrose house and grounds dating back to the turn of the twentieth century. The Kelly occupation of Melrose lasted until Ethel Kelly's death in 1975, and NPS investigations into the Melrose barn and carriage house have catalogued hundreds of site-specific tools and other camping, hunting, gardening, or automobile-related artifacts from this era.

With its inclusion in the first Spring Pilgrimage tours of Natchez historic houses in 1932, Melrose underwent the beginning of a significant transition from private home to tourist attraction. During the Spring Pilgrimage, Natchez ladies dressed in the historic costumes of their ancestors to receive visitors into their homes, and the promotion of Pilgrimage tours provided more occasions for early formal photography within the homes. A 1930s photograph of the Melrose drawing room presents two local women wearing black silk dresses associated with Elizabeth Davis and her daughter Julia—dresses now in the park museum collection—but it also provides important information about the fabric on original furnishings before their later reupholstering. Ethel Kelly directed the planting of masses of pink azaleas to beautify the property, and she added some of the fine historic furnishings from Choctaw to the original furnishings left behind by the McMurrans at Melrose. These included two sets of rich silk draperies—one rose and gold, and one midnight blue and gold—which she hung in the parlor and dining room at Melrose. She also installed the matching rose-and-gold-upholstered parlor suite of rococo revival furniture in the Melrose parlor, along with a rosewood piano and marble-topped center table and a walnut étagère. NPS curators have used the only existing historic photograph of the Choctaw interior to sort out the appropriate origins for some of the resulting blended collection of furnishings at Melrose. At the same time, the presence at Melrose of Jane Johnson provided an ongoing source of continuity and oral tradition at the estate. Both she and George Kelly lived until 1946.

After Ethel Kelly's death, Melrose was sold once again with most of the furnishings intact, this time to Callon Petroleum Company at the height of the 1970s oil boom. John and Betty Callon directed a massive restoration of the historic structures and grounds, which served as their private home, a venue for lavish corporate entertainment in a park-like setting, a bed-and-breakfast establishment, and the location for a number of movies shot over the following decade. The Callons considered preservation issues as part of their restoration, and NPS curators found cabinets in the Melrose attic filled with historic fabrics removed from furniture at the time of reupholstering. Fortunately the Callons also took hundreds of photographs documenting their Melrose projects, photographs which provide the only existing record of old chicken houses demolished and historic fence lines removed.

The 1990 purchase of Melrose by NPS after the oil boom went bust marked the estate's final transition, from 130 years as a private home to a house museum dedicated to historic preservation and interpretation. In the early years of the 1990s, NPS emphasized scholarly research and documentation of the estate's cultural resources. This took such forms as a full set of measured Historic American Building Survey (HABS) drawings and accompanying documentary photographs, a historic structures report, a cultural landscape report, and a historic furnishings report. A historic resource study encompassing all three Natchez National Historical Park units (Melrose, the William Johnson House, and the Fort Rosalie site) also included a new, more detailed National Register nomination for Melrose. This nomination ascribed national significance to those resources associated with the antebellum planter class (McMurran and Davis), state significance to the Kelly-era resources (based on their early historic preservation efforts and their role in the beginnings of heritage tourism), and local significance to the Callon-era restoration because of the importance of the 1970s oil boom to the local economy.

The round of historic reports generated by NPS relied on a variety of sources, including archival materials, oral histories, historic photographs, archaeology, and on-site investigations. A finishes analysis conducted by architectural conservator George Fore found very delicate interior painted finishes, such as pale rose glazes, on some plaster walls, and dark baseboards painted to resemble fine wood grain—all buried beneath nearly one hundred years of paint layers. Fore used historic photographs showing the tinted blocks and veins painted onto the exterior stucco surfaces of the mansion as the basis for his investigations of exterior marbleizing. These areas had also been covered with white paint since the first Kelly restoration projects of about 1903-1905. Similarly, the cultural landscape report team headed by Ian Firth and Suzanne Turner combined an examination of existing landscape features with historic maps of the property and related archival materials to recapture the original design elements of the Melrose grounds. The research efforts of all the reports were enhanced by oral history interviews with Fred Page, a current NPS tour guide who has worked in various roles at Melrose since 1950 and whose earliest memories of the Melrose mansion and grounds date back through changes made by the last two sets of private owners.

NPS implementation of the treatment recommendations that grew out of these reports has pushed Melrose into a new leadership role for Natchez historic houses. The park set a high priority on the installation of wheelchair-accessible public parking, pathways, and restrooms, as well as a wheelchair lift allowing access to the first floor of the mansion and a videotaped tour of the second floor. However, some of these changes at Melrose have violated local expectations for operation of a "tour house" that have developed since the 1930s. The removal of many of the pink azaleas planted by Ethel Kelly—overgrown by the end of the 20th century into massive thickets surrounding the mansion—provided one example. The NPS emphasis on accurate, scholarly interpretation rather than oft-repeated local mythology has provided another. In particular, NPS has made a major effort to incorporate interpretation of those slaves who lived and worked on the estate into the basic tours and exhibits at Melrose. This contrasted with an existing unwritten local code not to introduce “unpleasant” subjects such as slavery into house tours, a code preserving the illusion that paying visitors are actually guests in the historic homes. At Melrose, the slave bells on the back gallery of the mansion have become important artifacts treated with a level of care and concern comparable to that awarded to the high-style McMurran furnishings. Ironically, the NPS archaeological investigations of what was thought to a rare slave privy behind the remaining slave cabins on the estate revealed no materials that could be dated to the antebellum period and places construction of the structure more likely during the postwar Davis period of ownership.

The establishment of NPS standards for the exhibition of museum collections has created additional distinctions between Melrose and other Natchez houses. Installation of the reproduction Venetian blinds based on John McMurran’s letter helped to alleviate the completely dark setting for the furnished rooms created by initially closing the exterior shutters on the mansion to prevent light damage. After the parties carried out at Melrose during the Callon years, NPS has imposed its museum standards for pest monitoring and control, which include prohibiting any food, drink, smoking, or fresh floral arrangements inside the Melrose mansion. Stanchions and ropes have been placed inside the mansion to keep visitors from wandering freely through the furnished rooms. In effect, NPS has exchanged the local tradition of hospitality for new paradigms of preservation and security. In that context, in 1997 NPS removed from exhibit the only original draperies left hanging in the house, a set of twelve-foot-high green silk panels with silk tassels and trim dating back to the McMurran era. Visitors familiar with the house and its contents lamented no longer being able to see the “real historic stuff.” But a collection condition survey carried out by textile conservator Jane Merritt of the NPS Harpers Ferry Center determined that the draperies were too deteriorated to remain on display. To preserve their value to researchers, Merritt oversaw their removal from the drawing room windows and preparation for placement inside a rolled textile storage cabinet in a modern museum storage building constructed by NPS on the rear of the Melrose property. NPS has subsequently installed reproduction draperies in the Melrose drawing room matching the pattern and color of the originals.

With its innovative status as a partnership park, Natchez National Historical Park has also crossed boundaries in providing new levels of interpretive guidance or technical assistance to other historic houses, or even to private individuals with collections of personal treasures. One method has been a series of public workshops on the care of historic houses and their furnishings. Since 1995, these workshops have been carried out more than twenty times in seven different states by the author (a museum curator), often in the context of meetings for historical societies, garden clubs, preservation groups, or state museum associations. These efforts have paralleled the interpretive outreach efforts of park ranger Janice Turnage, whose effective uses of specific historical information has made her much in demand as a public speaker to churches, civic groups, and other tourism agencies. In conclusion, the gathering and use of information across interdisciplinary lines, the integrated approach to planning and programming, and the setting of new standards for cultural resource management, interpretation, and outreach have all contributed to establishing Melrose as a multifaceted jewel in the National Park Service crown.

65 Implementing wetland protection for agricultural lands in Cuyahoga Valley National Park, Ohio

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Introduction

Balancing the protection of natural resources with those of significant cultural resources is an ongoing challenge for national park managers. However, by integrating science-based natural resource protection goals with cultural landscape protection initiatives, we may alleviate some of the potential conflicts inherent in multiple-use areas. The primary goal of the park manager is to maximize both natural and cultural resource values.

Congress created Cuyahoga Valley National Park in 1974 to preserve and protect historic, scenic, and natural resources for the recreational use and enjoyment of present and future generations. The park encompasses over 33,000 acres of relatively undeveloped land along 22 miles of the Cuyahoga River between the metropolitan areas of Cleveland and Akron, Ohio. Much of the park is currently forested, but other significant land-cover types include old field habitats, shrub and scrub, agricultural land, and wetlands.

Much of the valley was farmed in the past. While most of the park is now reforested, the rural landscape that characterized the valley is considered a cultural resource that requires protection. Short-term agricultural leases and traditional farming practices maintained by private landholders in the park have maintained some of this rural character. Under a new program called the Countryside Initiative, the park is taking a more active role in restoring agricultural activity on small, historical farmsteads within the park. Considering its national park setting, this initiative is promoting sustainable and ecologically friendly farming practices that avoid or minimize impacts on natural resources.

Status and importance of wetlands in Cuyahoga Valley

Wetlands are important natural resources that are often associated with potential farmlands. Wetland habitats in Ohio declined in area by 90% between the 1780s and 1980s (Noss and Peters 1995). Most of these losses can be attributed to draining and filling for agricultural use. Development and urban sprawl continually threaten the wetlands that remain in northeastern Ohio and around the park. As these wetland losses continue, the wetlands within Cuyahoga Valley become increasingly valuable at a regional level.

Healthy wetlands provide many benefits (Mitsch and Gosselink 1993). Water quality is improved as wetland areas filter out nutrient loads and pollutants before they reach rivers and streams. Wetlands provide habitat for a diversity of plants and wildlife, many of which are becoming increasingly scarce both locally and regionally due to continuing wetland losses. Wetland complexes also serve as important stopover areas for migrating birds. In addition to their ecological significance, wetlands exhibit a variety of educational, recreational, and aesthetic values.

It is important to note that while it is relatively clear how large wetland complexes provide these benefits, several recent studies have shown how small, isolated wetlands can be considered just as crucial for maintaining regional biodiversity (Dodd and Cade 1997; Semlitsch and Bodie 1998; Snodgrass et al. 2000).

From **Crossing Boundaries in Park Management: Proceedings of the 11th Conference on Research and Resource Management in Parks and on Public Lands,** edited by David Harmon (Hancock, Michigan: The George Wright Society, 2001).

In 1999, an ambitious wetland inventory was initiated at the park to help characterize wetland resources for planning, environmental review, and restoration purposes. Potential wetland areas were identified, classified according to the national wetland classification standard (Cowardin et al. 1979) and mapped. Information on wetland type, dominant vegetation, hydrology, presence of exotics, and restoration potential was collected and linked to a geographic information system (GIS).

This inventory revealed more than 1,200 wetlands totaling over 1,700 acres in the park (Davey Resource Group 2001). Most of the wetlands are quite small, with only 190 greater than an acre in size and only 35 greater than 10 acres in size. A wide variety of wetlands was identified. A few large inundated wetlands are found where natural hydrology has returned or where beaver *(Castor canadensis)* have altered flow regimes. Much more typical are small emergent wetlands that have become established in areas previously disturbed by humans. Tiny pockets of emergent wetlands have become established in some areas as a result of previous use of the landscape, including small depressions, tire-rut wetlands, and roadside ditches. Additionally, hillside seeps generate small wetland areas adjacent to many previously farmed areas.

Wetland protection guidelines and regulations

Executive Order 11990, "Protection of Wetlands," directs federal agencies to minimize the destruction, loss, or degradation of wetlands, and to preserve, enhance, and restore the natural and beneficial values of wetlands. National Park Service (NPS) policies for implementing this order are found in Director's Order 77-1, "Wetland Protection," and the associated procedural manual. NPS requires that parks avoid adverse impacts to wetlands to the extent practicable for any new development or projects. Proposed actions that have "potential direct or indirect adverse impacts" require special National Environmental Policy Act (NEPA) compliance procedures.

Agricultural activity poses potential threats to wetlands by direct encroachment, nutrient enrichment from fertilizers and animal waste, chemical and pesticide pollution, introduction of exotic plants through feed or plantings, and edge effects from field clearing (e.g., increased cowbird parasitism). Indeed, human activities (e.g., forest clearing, paved roads) may negatively affect wetlands in a variety of ways at distances of up to 2 km (Findlay and Houlihan 1997). Effective buffer zones can be established to minimize and avoid potential adverse impacts.

Under the Countryside Initiative, numerous farm fields associated with proposed farmsteads would need to be assessed for potential wetland issues each year. A standard procedure for screening farm fields to identify the potential for impacts was required. This paper outlines the specific protocol Cuyahoga Valley National Park has developed for implementing NPS wetland protection policies on proposed agricultural lands.

Wetland protection protocol

To assess the potential for wetland impacts, a simple protocol was established (Figure 65.1). A *wetland identification process* determines whether wetlands are associated with proposed farming areas. If wetlands are not present in a proposed farm field, then it is obvious that no impacts are expected. If wetlands are associated with a potential farm field, then the potential for direct or indirect impacts must be assessed.

A *wetland quality assessment* is conducted and then *wetland buffer recommendations* are assigned. If direct encroachment into wetland areas can easily be avoided, then no potential exists for direct impacts. In almost all cases, the park will explicitly avoid direct impacts to wetlands. If effective buffer zones that protect the wetland values and functions can be established, then no potential indirect impacts are expected. After initial buffer recommendations are set, *buffer zone adjustments* may be made and efforts for *monitoring buffer effectiveness* are established.

If, through this screening process, it is uncertain whether direct or indirect impacts can be expected, or if some impacts may be unavoidable, then areas would either be explicitly excluded from agricultural use or assessed using the standard NEPA compliance procedures.

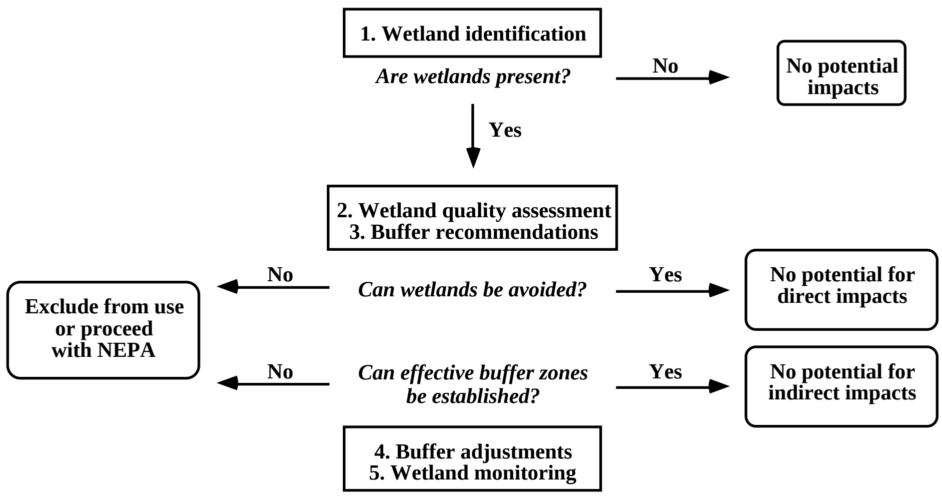

Figure 65.1. Wetland protection protocol for agricultural lands.

Wetland identification

Parcels proposed for agricultural use are reviewed to identify potential wetland issues. All existing information is reviewed, including GIS data layers, the park wetland inventory, National Wetland Inventory, Ohio Wetland Inventory, county soil surveys, and hydrology. Field visits are conducted to confirm initial findings and identify other potential wetland areas through observation of vegetation and hydrology. Any areas that have documented wetlands or wetland indicators in the proposed use area or within approximately 200 ft of the edge of the proposed use area are referred to a qualified wetland specialist for assessment.

The wetland specialist then conducts a wetland determination for the identified fields. This determination will include marking and mapping the boundaries of any wetlands and reporting on their size and quality, characteristic vegetation, and hydrology. Some detailed information collection performed in formal wetland delineations (e.g., paired sampling along boundaries) will be abbreviated, as such accuracy is not critical unless planning for mitigation. All wetlands identified on or near proposed farmlands undergo further review for buffer recommendations.

Importance of wetland buffers

Wetland buffers are vegetated areas that reduce the adverse impacts to wetland values and functions from adjacent land use. An excellent overview and literature review of the roles of wetland buffers and effective buffer sizes is available (Castelle et al. 1992). Buffers protect wetlands by moderating the effects of storm water runoff—stabilizing soils, filtering harmful substances, reducing sedimentation and nutrient input, and moderating water level fluctuations. Forested buffers shade waters, thereby moderating temperatures and oxygen levels for aquatic wildlife.

Buffers also provide essential wildlife habitat for feeding, roosting, and breeding. Buffer areas afford cover for safety and thermal protection. For example, many waterfowl species feed in wetlands but build their nests on adjacent dry land to avoid flooding nests. Some bird species, such as the wood duck *(Aix sponsa)* and pileated woodpecker *(Drycopus pileatus)* require large dead trees in wetland margins for nesting. Many amphibians spend only a small portion of the year in wetland areas, dwelling in terrestrial habitats adjacent to ponds and wetlands during other seasons.

Wetland buffer sizes

Buffer size recommendations will vary depending upon wetland function and value. A general summary of the values affected by a variety of buffer sizes is found in Table 65.1. Buffers narrower than 50 ft are generally ineffective or minimally effective in protecting wetlands (Castelle et al. 1992). Therefore, buffers narrower than 50 ft should be assigned only to very small, low quality, human-made wetlands (e.g., roadside ditches, tire-rut wetlands). Buffers designed to maintain water quality are generally on the order of 100 ft (Castelle et al. 1992).

Buffer size (ft)	*Responses of wetland values and functions*
300+	Waterfowl breeding/feeding retained [1] Heron feeding maintained [1] Amphibian populations retained [3] Diversity of mammals maintained (e.g., beaver, muskrat) [1] Cavity-nesting duck habitat protected [1] Bird diversity maintained [1]
200-300	Waterfowl breeding, but reduced diversity [1] Reduced mammal diversity, but beaver remain [1] Most sediment removed [1]
100-200	Waterfowl breeding, but reduced populations and diversity [1] Adequate sediment removal (75-80%) [1] Most nutrients filtered [1] Reduced salamander diversity [3] Decreased turtle abundance [2]
50-100	Loss of many wetland bird species (e.g., belted kingfisher) [1] Songbird diversity maintained in forested buffers [1]
<50	Generally ineffective in preserving major wetland functions [1] Human activities disturb breeding and feeding birds [1] Degradation of buffer habitats over time more likely [1]

Table 65.1. The responses of wetland values and functions to various buffer sizes. Sources: [1] Literature review by Castelle et al. 1992, [2] Burke and Gibbons 1995, [3] Semlisch 1997. Note: Specific research results were generalized into the above categories for ease of interpretation.

However, buffers designed for habitat protection goals are generally larger depending on the specific fauna involved. Narrow buffers in areas naturally rich in wildlife can act as ecological traps by increasing predation risks and reducing reproductive rates, possibly leading to population declines and localized extinctions. Nesting waterfowl generally require buffers of 100 ft or more to maintain diversity and abundance (Castelle et al. 1992). Some pond-breeding salamanders found in the park *(Ambystoma* spp.) can require terrestrial buffers of several hundred feet from wetlands for adequate protection (Semlitsch 1998). An approach that considers all of these buffer values is appropriate in a national park setting.

Wetland quality assessment

An assessment of the specific wetland functions and values for each wetland area is needed to establish appropriate protective buffer zones. Rather than study each wetland area in depth, the park has adopted a robust rapid assessment technique. The Ohio rapid assessment method for wetlands (ORAM) is used by the Ohio Environmental Protection Agency as guidance for assessing wetland quality and landscape context (Ohio EPA 1999). This is an adaptation of a wetland assessment technique established by the State of Washington (Washington State Department of Ecology 1993).

The ORAM scores wetlands based on a number of wetland characteristics, including presence of threatened or endangered species, exotic species, total area, vegetation classes and structure, plant diversity, special habitat functions (e.g., heron *(Ardea herodias)* rookeries), hydrological connections and corridors, existing buffers, and adjacent land uses. Assessments of wetland quality include both office and field ratings. Office ratings use information gathered during the delineation as well as other data. Field ratings include assessing many qualitative and quantitative wetland characteristics in a simple, straightforward manner.

The ORAM uses a standardized scoring system that classifies wetlands into three quality categories: "very low," "moderate," and "very high." In the park, four wetland quality categories will be used, with the "moderate" class split into two to ensure that larger buffers are provided to wetlands approaching "very high" quality. Initial category assignments provide a starting point for prescribing effective buffer zones.

Standard buffer recommendation

Wetland buffer recommendations are based on wetland quality. Generally, sensitive or unique wetland areas would require larger buffers and low-quality areas would require smaller. Wetland buffers in Cuyahoga Valley National Park will be established from a minimum of 25 ft to 200 ft or more. The initial buffer categories based on wetland quality are:

- Category 1, very low quality: 25-50 ft
- Category 2a, moderate quality: 50-125 ft
- Category 2b, moderate quality: 125-200 ft
- Category 3, very high quality: 200+ ft

This range includes distances similar to those established by some states that have adopted wetland buffer zone standards (Castelle et al. 1992). Only tiny tire-rut and roadside-ditch wetlands would receive buffers narrower than 50 ft. Buffers of 50 ft are recommended for all other low-quality wetlands. Buffer sizes then increase with increasing wetland quality. These increases track closely with the scope of wetland functions requiring protection.

Buffer zone adjustments

NPS wetland protection guidelines also promote restoring and enhancing wetland quality and value whenever practicable. Therefore, the current quality of a wetland is only one consideration when determining buffer needs. If wetland quality can easily be improved with restoration or removal of invasive species, then such a wetland should be afforded additional protection. As such, wetlands are qualitatively assessed for restoration potential during field visits. Considerations include current quality, accessibility, presence, extent and type of exotics, presence of human-made impediments, connectivity to other wetlands, and aesthetic value. A high restoration potential may justify raising the initial buffer recommendation.

Alternatively, much of the scientific literature assessing the adequacy of buffers for protecting against agricultural impacts is based on research on traditional agricultural practices. Using these recommendations can therefore be considered conservative and sufficiently protective in respect to more sustainable practices.

Less intensive sustainable and organic farming practices may justify smaller wetland buffers. Indeed, the actual use of buffer areas for certain agricultural activities may be allowable where such activity has been shown to enhance buffer zone quality or not adversely impact wetlands. For example, prescribed grazing practices may enhance wetland values by controlling exotics and increasing habitat for rare species in some situations (cf. Tesauro 2001). Documented scientific research justifying reduced buffer sizes or agricultural uses of buffer areas would be required before any such program is considered. Additional environmental compliance activities, mitigation, and monitoring would probably be required in most cases.

Monitoring buffer effectiveness

As much of the focus of this plan is to avoid indirect impacts on wetlands through the use of buffer areas, monitoring protocols will be set in place to ensure that the buffers are indeed performing their function. Using generally conservative recommendations does not remove the responsibility of monitoring buffer effectiveness.

A comprehensive wetland monitoring program is currently in development. Some monitoring efforts will integrate with established projects. For example, established frog call surveys and water quality monitoring efforts will be expanded to include water resources associated with new farm areas. Additionally, wetland vegetation monitoring involving quantitative assessments of exotic species and cover board readings to document changes in vegetation in wetland margins will be implemented. Buffer zone photo documentation along the length of wetland buffer and farm field boundary will provide lasting visual records. Other wetland monitoring tools are being investigated for use in the park (Danielson 1998). Baseline monitoring data are being collected before farming activity begins and will then be reassessed periodically to assess changes and trends.

Additional applications

This paper outlines the standardized procedures and protocols by which wetland protection is being integrated into a new sustainable agriculture initiative in Cuyahoga Valley National Park. However, the same principles and practices can certainly be extended to other park development projects, other significant natural resources requiring protection (e.g., riparian zones), and other NPS units.

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66 The next evolution of resource stewardship

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The National Park Service (NPS) has made significant strides toward detecting, quantifying, and mitigating threats to the resources under its stewardship. Despite these efforts, important natural and cultural resources of the National Park System are suffering long-term derogation.

This resource harm is the result of the complex interplay of causative factors. These include robust international markets for protected area products; increases in global traffic, resulting in higher rates of introduced pests; scarcity of valued resources; interstate pollution; and habitat lost to development pressure. Resources are harmed by misuse, overuse, or exploitation for selfish gain. These inter-related and rapidly evolving resource risks strike at the core of the agency mission.

Initiatives such as inventory and monitoring programs, Ranger Careers, and the two resource initiatives are essential building blocks for the agency. They define the professions and begin to provide the science required for sound decisions. However, these initiatives were constructed apart from each other. It is unsurprising, therefore, that in important ways our professions do not fully complement each other. There remains a gap between scientific knowledge of resource harm and the application of advanced tactics capable of mitigating the threats. This results in a disjointed application of NPS assets that seriously reduces our agency's effectiveness in halting resource degradation.

It is time now to look beyond these programs to a Servicewide strategy that ensures that park managers have available to them a modern suite of capabilities necessary to accomplish the agency's mission in the 21st century. This means guiding the growth of these individual initiatives so that they mature into one integrated program. Our success, though, also requires overcoming several other organizational limitations standing in our way. Until these conditions are corrected, we risk a continued decline in the health of the resource. What follows is a discussion of these hindrances and suggested solutions.

NPS protective efforts are self-limited by administrative boundaries

NPS areas with similar resource sets have an uncoordinated response to threats. Transboundary threats are mitigated in a piecemeal fashion. NPS integration with other resource conserving agencies is rare.

It was said years ago at Vail. It has been said by many since. It bears repeating: few modern resource threats arise solely within NPS boundaries. Fewer still affect only park resources. Rarely can any of them be effectively mitigated by independent action at the park level. However, most NPS resource preservation efforts are focused within the boundaries of individual park units.

Effective cooperation between NPS units, and especially between the NPS and other conservation agencies, is not widespread. For example, despite considerable anecdotal evidence for the emergence of international markets in wild-grown mushrooms, and evidence of significant takings from protected areas, the NPS lacks a unified strategy to assess the impacts on the park system.

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Similarly absent are unified strategies for evaluating and—where deemed inadequate—attempting to improve state and national regulations. Missing also are widespread investigative efforts to determine where linkages exist in parks that experience similar exploitative activities. Meager within the agency, coordination with other resource-serving agencies is even less present.

Solution: Reach out beyond park boundaries to protect resources in their "range." If our science partners are correct, preservation of protected area resources hinges upon the health of their ecosystems. Therefore, NPS must operate within ecosystems with two broad goals: (1) mitigate transboundary threats, and (2) provide leadership, technical and financial assistance, and coordination to conservation agencies whose objectives compliment those of NPS. In order to meet its own mission, it should be the duty of NPS to provide this leadership. If not us, who?

Nobody understands this approach better than the managers engaged in the struggle for the Everglades, whose greatest threats are external. We must follow the lead of those superintendents who have stepped boldly outside of park boundaries. They appreciate that, when treating any resource decline, we need to be alert to patterns and trends occurring elsewhere within the biome.

As coveted resources decline outside parks, pressures build within the boundaries. If we are to succeed in our efforts, we must demonstrate leadership and develop partnerships with other resource stewards with complementary concerns.

NPS enforcement capabilities have not evolved to meet emerging threats

The NPS enforcement model that has developed over the years has been based on deterrence provided largely through random patrols and a reactive investigative capability. Clearly, this program has effectively deterred some criminal activity found in our parks, particularly in the realm of public safety. However, modern resource threats, especially those that transcend boundaries or include commercial trade in coveted resources, require additional capabilities.

Rangers have a long and admirable history in the defense of the parks and the people who come to them. Meeting the needs of NPS has required major changes to the protection program over the years. The 1970s and 1980s saw the protection discipline adopt a more professional approach to law enforcement to meet increasing criminal threats to visitor and employee safety. This included the addition of a modest investigatory capability.

The enforcement model that NPS has applied, though, has not changed much since the agency's inception. It is based largely on deterrence patrol. Limited investigative assets have generally been used reactively, once crimes have been detected. Given adequate staffing (which has rarely been the case), this traditional model is probably effective in dealing with many of the types of crimes against people, property, and the resource we typically experience in the parks. This model, however, is ineffective against many of the threats that have emerged towards the end of the 20th century. With increasing intensity, our parks are experiencing exploitive crimes by individuals working alone or in groups. These technologically advanced violators repeatedly assault resources in an organized, preplanned manner.

Not unlike any other law enforcement agency facing some sort of organized criminal activity, a more complex model is required. It requires more focus on proactive investigation. It requires an infrastructure for collecting, sharing, and analyzing information. It requires us to work with partners beyond our boundaries and to employ such strategies as covert operations. It requires a protection ranger workforce that is skilled and routinely focused on resource protection law enforcement. What the resource requires, now, is for the protection function to take another stride forward.

Ranger Careers and the beginnings of an investigative function provide a solid launching point for NPS. Gaining flight is hindered by the absence of strategic planning, centralized leadership, and a global view of resource threats. The national protection infrastructure, never robust, has deteriorated to the point it cannot effectively provide unifying leadership. As a result, the protection function is fragmented and wrought with inconsistencies in focus and capability.

Solution: Construct an infrastructure to formulate and implement new strategies within a revised protection model. We are just learning to apply the professional assets provided by Ranger Careers to reverse exploitative resource derogation. Examples of effective strategies developed in the field and implemented locally can be found throughout the park system. Exporting these solutions to other areas facing similar threats requires coordination, support, and accountability. Crafting new solutions requires an infusion of energy.

Just as important, the agency must, for the first time, structure its enforcement, compliance, and regulatory capabilities based upon a rigorous examination of "What does the resource require?" We require greater infrastructure at the national and regional level focused on providing this leadership. This infrastructure should be crafted to:

- Fully implement the vision of Ranger Careers based upon a model that requires prevention, detection, intelligence-gathering, and investigation;
- Forecast emerging threats by investigating global events and cultural and economic factors that affect resource demand;
- Ensure the effective integration and sharing of assets among agencies with similar regulatory and enforcement interests;
- Aggressively craft and deploy new legal tools, such as civil actions for resource restoration;
- Lead such tactics as interagency task force operations against transboundary threats; and
- Support covert operations against organized criminals.

These capabilities are urgently required. Without effective deployment of its protection assets, NPS cannot achieve its mission.

NPS workforce assets are not consistently focused on resources most at risk

Protection assets are not necessarily focused on the urgent resource risks identified by the scientific community. Typically, the agency's protective strategies tend towards unfocused efforts to protect "the resource" as a whole, without a clear understanding of which specific resources most urgently require protection. Tremendous effort may be expended protecting apparently stable species, while threats to seriously declining—but less visible—resources go unchecked.

Considerable assets, for example, may be expended against unlawful taking of deer, while less visible takings of threatened plant species goes unchecked. Compounding the risk, science assets responsible for judging species stability may not fully understand the levels, persistence, and degree of risk posed by exploitative takings. For example, we may not fully understand the effects on an apparently numerous population if the best genetic material is being culled from it.

Three factors restrict our ability to focus assets appropriately. First, the scientific capabilities to monitor and study NPS resources are not yet distributed broadly enough. We can hope that the resource initiatives will substantially solve this deficiency. Secondly, we lack a mechanism to detect, study, and quantify the levels of exploitative takings directed at protected area resources. A complete understanding of the level and urgency of resource risk requires the coordinated efforts of the science and enforcement branches. In many areas this level of internal coordination is not well established. Thirdly, we lack a mechanism for cooperative establishment of priorities.

A broader concern lies in the ability of park workforces to apply effective energies towards protecting natural and cultural resources at any level. Enforcement personnel are often overwhelmed dealing with public safety threats; interpretative resources are stretched thin providing basic visitor services; resource management personnel devote their time reacting to damage after it has occurred; and science specialists are so backlogged inventorying and monitoring the resources in their parks that little remains for finding ways to implement protective strategies. This shortage of workforce assets to get the job done is widely understood.

Solution: Develop resource threat assessments. A strategic planning process aimed at protecting resources begins with identifying and prioritizing specific threats. Although this may seem like common sense, this disciplined evaluative process is not widely used. There is likely a relatively small number of park managers that have a full understanding of exactly which resources under their care are threatened, the extent, and the specific sources of those threats. Even fewer have clearly defined the priorities that ultimately drive the protection efforts by all divisions. Our capabilities for doing this in the past were severely hampered by a lack of inventorying and monitoring. Although NPS is currently taking great strides to strengthen these assets, the discussion doesn't end here. Besides having the means to collect data, we need to also have in place a process to evaluate the information. The process for doing this should be a formal one.

Further, the information needed to identify and quantify such threats does not only originate from scientific assets, but also through the research and knowledge acquired from the enforcement staff. As illustrated in the mushroom theft scenario, enforcement can reasonably be expected to provide investigative information on the economic incentives, market factors, existing and predicted commercialization levels, and the level of targeting of protected areas. Science can be expected to contribute information on the direct impact of these takings, as well as secondary impacts such as trampling, removal of food from other species, and changes in soil chemistry affecting the survival of other plants. While mushroom taking is among the simpler resource risks facing us, it quickly becomes apparent that effective priority-setting and mitigation requires the ability to assess resource threats from different perspectives simultaneously.

Although the development of sound processes for doing comprehensive threat assessments have yet to be engineered, Figure 66.1 describes an overall framework.

Our resource sciences, enforcement, and education assets rarely take integrated action against resource threats

Each discipline demonstrates a strong commitment towards protecting park resources and can point to successes. However, there is insufficient communication of resource risks among disciplines and little joint planning to combat threats. We are just beginning to understand the critical role played by each discipline and how our future success will depend on a fully integrated effort by all park workforces.

Effective protection requires long-range planning that explores tools for mitigating threats, promotes partnerships, and integrates the prioritization and allocation of fiscal and personnel assets. In NPS, work planning and the application of fiscal assets are typically done within operational spheres. Holistic approaches to protection are rare.

Solution: Target NPS assets to enable coordinated mitigation of specific resource threats. Though individually committed towards resource protection, each discipline typically operates independently of one another.

Within the last decade NPS has positioned itself to meet the resource stewardship challenges it will face in the 21st century. Ranger Careers has redefined the professional skills and abilities needed of its front-line enforcers and educators. The two resources initiatives are establishing the scientific research and monitoring that are critical for good decision-making. Collectively, these disciplines are the core of our workforce assets charged with the responsibility of halting the derogation of resources.

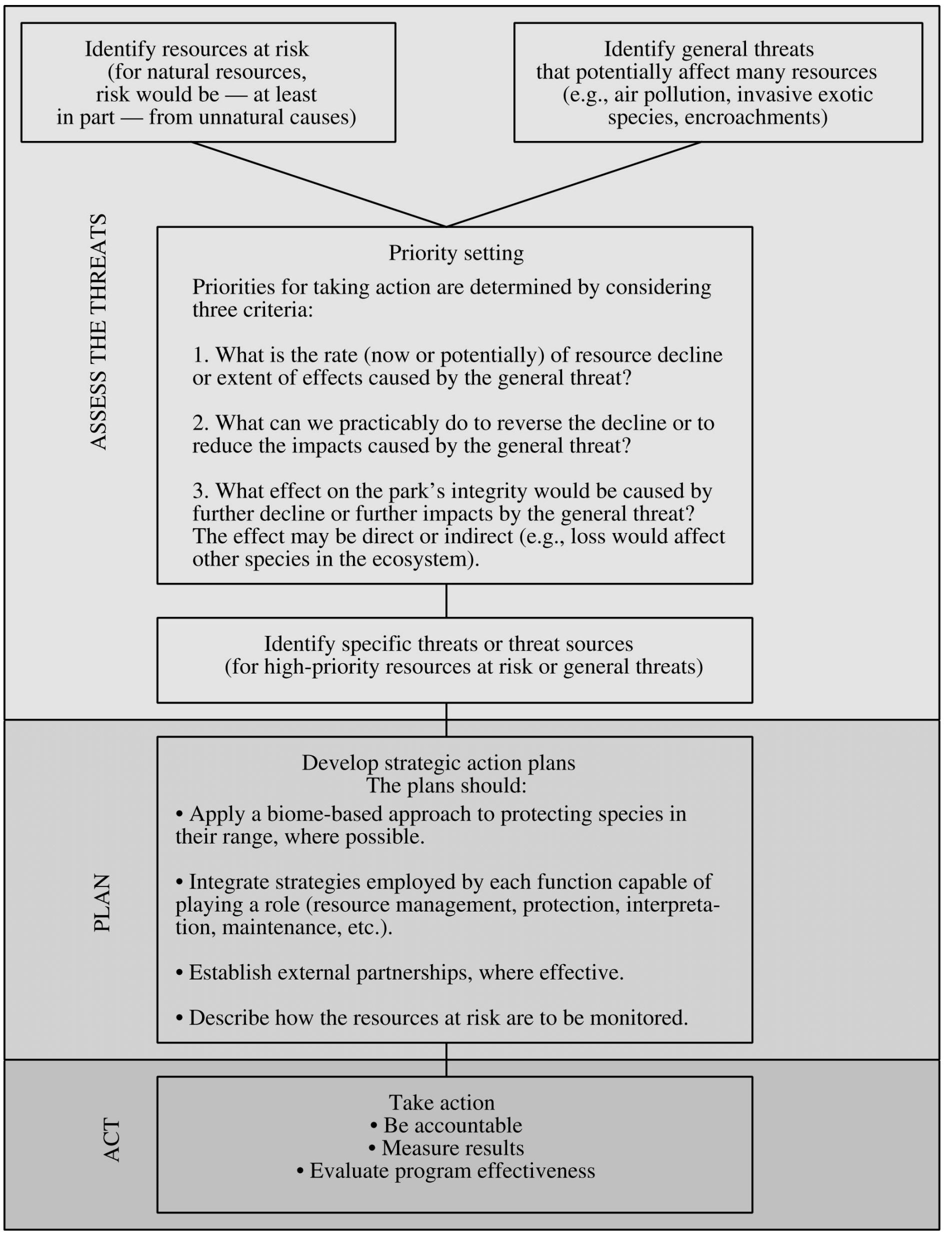

Figure 66.1. Resource stewardship blueprint.

Strengthening old programs and developing new tools within our disciplines is not enough, however. We are beginning to appreciate that if we are to succeed, we must understand that each discipline cannot work within a vacuum. Effective stewardship requires an integrated program. This program consists of four critical components working in a unified fashion: resource sciences, mitigation, compliance, and education (Figure 66.2). If any side of this program is weak, then the entire structure loses integrity. Independent action by any discipline may also weaken an effective resource preservation structure.

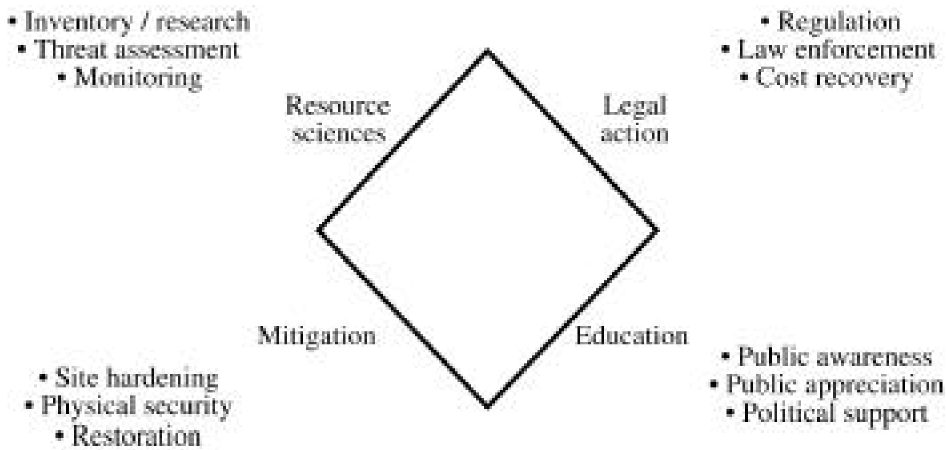

Figure 66.2. An integrated program for effective stewardship.

Once a truly integrated working atmosphere exists within a park, one further step is needed: a precise application of mitigation tools to specific, well-quantified threats. These tools will be taken from a complete and focused suite of resource protection tools (Table 66.1).

Table 66.1. Resource protection tool suite.

Compliance tools

- Investigate proactively to determine values at risk
- Monitor resources at risk from criminal activity
- Monitor to ensure NPS compliance policies are observed
- Patrol to deter and detect
- Do covert investigations to deter and detect illegal takings
- Perform criminal investigations to deter and eliminate persistent and complex derogations
- Alter NPS regulatory patterns
- Ensure NPS needs are integrated into international, federal, and state regulatory patterns

Science tools

- Inventory to establish values at risk
- Targeted monitoring of species at risk
- Research to isolate mechanism of species decline

(Table 66.1, cont'd)

- Define ecosystem boundaries for cooperation with others
- Replicate resource to restore populations
- Develop techniques for resource marking and forensics

Education tools

- Change patterns of use among visitors
- Affect patterns of use of targeted species at all locations
- Targeted programs for populations at risk for resource violations
- Skills education for cooperating agencies (e.g., U.S. Customs, etc.)
- Skills education for resource industries

Management tools

- Establish ecosystem-based cooperation targeted to species at risk
- Cooperate to develop lawful sources of scarce resources

Conclusion

Since its inception, NPS has been battling threats against the parks. The nature of these threats, though, has changed over the decades. At the beginning of the 21st century we see the rise of two areas of threats, neither of them novel: those from external sources, such as pollution, neighboring development, introduction of exotics, intercepted water flow, etc., and the theft of specific coveted resources, often for monetary gain. Though there are many other types of threats to the National Park System, these are two areas where we are losing ground. They require special mitigating strategies.

No longer will it be adequate for successful superintendents to simply order the workforce to protect the resource as a whole. Effective mitigation requires a more focused approach. It means targeting resource science, education, enforcement, and other capabilities toward specific threats to specific resources. Success requires the close integration of these assets to determine what resources are at risk, to identify priorities for taking action, and to focus activities by all disciplines.

Effective mitigation requires reaching beyond park boundaries to protect resources in their range or to alter activities that affect resources within parks. Partnerships, task forces, political liaisons, and educational outreach often provide the means for such efforts. Slowing criminal theft of resources in the new century will require capabilities not now widely distributed within the enforcement discipline. It requires a strategic planning process that closely bonds the efforts of science, resource management, and enforcement. The ultimate reward, of course, will be improved health of the resource.

67 Protecting public health at Lake Powell

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Only few years ago, Lake Powell, the centerpiece of Glen Canyon National Recreation Area, was beginning to have the reputation as a dirty lake. A number of beaches had been closed due to bacterial contamination. Exhaustive efforts were undertaken by the National Park Service (NPS) in cooperation with the states of Arizona and Utah to improve the water quality and protect public health at Lake Powell.

Improving the water quality of Lake Powell is a large task if only because of the lake's size. The mainstem is nearly 200 miles long. Covering 163,000 acres, the lake is composed primarily of flooded canyons. All of the sinewy passages create a shoreline that is 2,000 miles long, roughly equal to the entire West Coast of the contiguous USA. Scattered along that shoreline are an unknown and variable number of beaches that are used for extended camping trips by nearly 3 million people every year.

In 1995, twelve beaches were closed to due to violation of state bacterial standards. The bacteria are an indicator of fecal contamination, which presents the possibility of disease transmission during water-based recreation. To avert future public health hazards, Utah, Arizona, and NPS entered into an agreement and strategic plan to protect the water quality at Lake Powell.

The plan included a wide range of strategies to affect visitor behavior and develop scientific understanding. Intense recreational pressure on the lake was presumed to be a large source of the problem. Educational efforts, rule changes, and facility improvements gave visitors the awareness and means to act responsibly. To assure that the best science was used to deal with the issue and that public health was adequately protected, the Lake Powell technical advisory committee (TAC) was created. The TAC expanded beach monitoring on the lake, established health standards and protocols for sample collection and processing, and identified areas where additional research was needed.

The plan called for outreach. Clear public notification protocols were established for when beach closures occur. Public meetings were held to scope out interested parties and public opinion. A contact list of enforcement, education, and public health agencies was developed, providing a bank of expertise from which the TAC was drawn.

The current laws were evaluated and changes were made to the superintendent's compendium requiring all lake-campers to have toilet facilities on their boat or carry a porta-potty. All marine sanitation devices (MSDs) must be emptied only at approved dump stations and be incapable of overboard discharge. Law enforcement agencies active on the lake, including Arizona and Utah State police, the U.S. Coast Guard, and NPS, were coordinated.

From **Crossing Boundaries in Park Management: Proceedings of the 11th Conference on Research and Resource Management in Parks and on Public Lands,** edited by David Harmon (Hancock, Michigan: The George Wright Society, 2001).

Education figures prominently in the plan. An education program was begun to raise visitor awareness of the procedures and importance of proper human waste disposal. Visitor education encompasses numerous signs and displays at all marinas, visitor centers, and remote access points. Rangers make contacts on the launch ramps and patrol large areas, contacting campers to educate them about the regulations and check for compliance. Visitors tend to want to do the right thing when armed with a little information; nobody wants to swim in contaminated water or tarnish the pure waters of beautiful Lake Powell.

Many facility improvements were outlined in the strategic plan. All marina pump-outs were expanded. The wastewater treatment facilities were evaluated for adequacy. Floating pump-out docks were deployed in remote locations. Additional shore-based toilets and dump stations were installed. Porta-potty cleaning stations were incorporated into all dumping facilities. Entrance stations were built as part of the Fee Demo program to provide a means for the dissemination of information and the collection of fees to fund many of these efforts.

Consensus was built with the concessionaire, who shared an interest in preserving Lake Powell. Porta-potties were stocked in marina stores. All rental boats were brought into compliance, and all new and refurbished rental boats are configured to contain even graywater. Marina boat slip rentals require that the boat be inspected for MSD compliance.

The Lake Powell TAC is composed of over 20 experts in the fields of public health, microbiology, and environmental quality. Members represent interested agencies and organizations including the Arizona and Utah Departments of Environmental Quality, Navajo Nation Environmental Protection Agency, U.S. Environmental Protection Agency (EPA), Northern Arizona University, Utah State University, University of Utah, Utah Department of Health, Southeast and Southwest Utah Public Health Departments, NPS Intermountain Region, NPS Water Resources Division, and Glen Canyon National Recreation Area. Arizona, Utah, and NPS agreed that decisions made by the TAC would be acceptable to all parties.

The strategic plan called for the seeking of a "no discharge" designation for Lake Powell from EPA. The joint application from the states of Utah and Arizona was coordinated through the TAC. The TAC was an excellent avenue for creating the application because both states are represented. EPA required proof of adequate wastewater treatment facilities and convenient dump stations. The facility improvements outlined in the strategic plan and implemented in subsequent years easily met EPA's requirements, and the "no discharge" designation was granted in the summer of 2000.

A beach monitoring program on Lake Powell began in 1988, and made it possible to identify the public health hazard. Under the guidance of the TAC, the Lake Powell beach monitoring program has blossomed into a model program with national recognition. Certified through the Utah Department of Health, the park operates two laboratories to cover the vast distances on the lake without exceeding sample holding time. Laboratory certification ensures confidence in lab results and legal defensibility to support regulatory action.

About 30 routine sites are monitored at least every other week. The first routine sample list was developed from personal knowledge of heavily used areas of the lake. The TAC established protocols by which beaches can be added and dropped from the list. Any routine beach that has not had a high bacterial count in three consecutive years can be dropped. Some beaches meet this criterion, but remain on the list due to high visitor use. Any beach that experiences a closure is added to the list. All ranger boats are equipped with sampling kits, which including sterile sample bottles, gloves, data sheets, and instructions for sampling non-routine beaches and other areas any time a problem is suspected.

Routine sampling is also augmented with randomized sampling. A customized geographic information system (GIS) project allows beaches to be randomly selected for sampling. The lake has been divided into 13 zones from which random beaches can be selected differentially, allowing the sampling effort in each zone to reflect the zone's needs and logistical constraints. Through random sampling, the beach monitoring is truly lakewide, even remote areas are monitored, and the potential to identify new problem areas is increased.

While protecting public health is the purpose of the beach monitoring program, beach closures must be taken very seriously and only be enacted when they are scientifically warranted. Beach closures unduly influence the general perception of water quality in the lake and cause economic repercussions in the local communities. It was important that the TAC clearly define a beach closure protocol that is protective of public health and responsible within the scientific context of the testing being done.

To maximize the number of areas tested, most beaches are sampled by taking a single sample. The TAC established sampling protocols and standards. Samples are collected from 4 inches beneath the surface adjacent to the selected beach where the water is 4 feet deep. This standardization focuses sampling on the most likely source of exposure during beach-related water recreation. Because Lake Powell crosses the border between Utah and Arizona, which have separate bacterial concentration standards, the TAC established standards to be used throughout the lake. Two sample-processing methods and indicator organisms are used to incorporate the best science into a political compromise between the states.

When a problem is detected, the area is re-sampled. Re-sampling continues daily until the problem is over. During re-sampling, multiple samples are taken along the beach to better estimate the true concentration of bacteria present in the strip in water defined by the sampling protocol. Because both sample-processing methods require 24 hours to complete, the re-sampling step is very important. By the time the first sample results are known, the condition at the beach may have changed. Re-sampling identifies the persistent contamination events that warrant reaction, and the sample replication provides confidence to support the presumption of predictability inherent in the use of a 24-hour test to determine closures.

After a beach is closed, at least five days' worth of samples must be collected for the beach to re-open. When the most recent sample as well as the most recent 2-, 3-, 4-, and 5-sample geometric means are all within the established limits, a beach can re-open. Such a conservative beach re-opening protocol ensures that the problem is over before a closure is lifted.

The TAC has also identified additional research needs and participated in studies related to the problem. Correlations between visitor-use statistics and bacterial counts were explored. Comparisons between the concentrations of the two indicator organisms have been done. The spatial variability of bacterial counts along beaches was examined. A microbial source-tracking study identified the various sources of contamination, including humans, cattle, and wildlife. A long-term study has been started to monitor the amount of human waste left on the beaches.

The exhaustive efforts of the strategic plan seem to have been a great success. Today, beach closures are very rare: there was one in 1999 and none in 2000. Even more telling than the frequency of beach closure is the total number of high bacterial counts detected. In the first year after adoption of the strategic plan, the number of high bacterial counts detected at beaches dropped from 95 to 31 (Figure 67.1). The number of high counts has continued to drop, with only a single instance during the 2000 season.

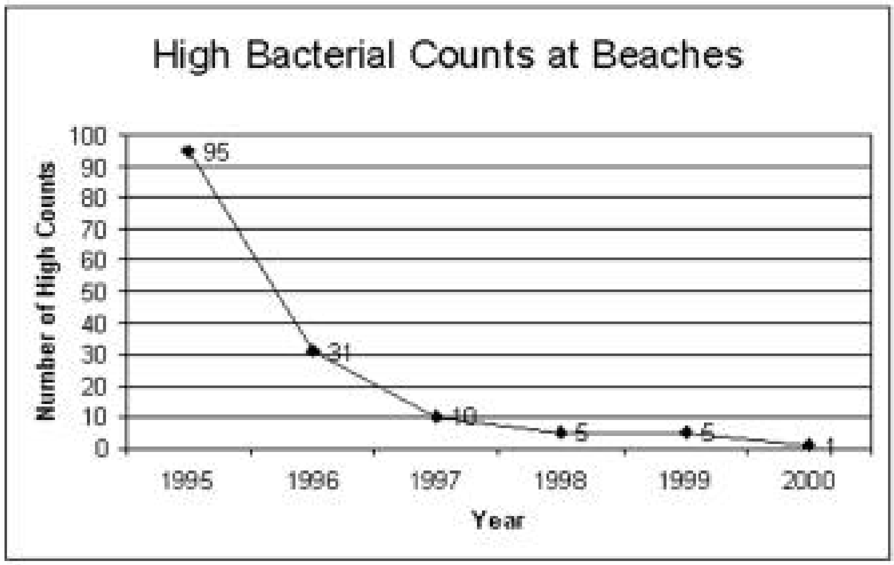

Figure 67.1. High bacterial counts at Glen Canyon National Recreation Area beaches, 1995-2000.

68 Integrated pest management: What is it? What has it done for the National Park System?

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Background

For the last 21 years, a method known as integrated pest management (IPM) has been the cornerstone of the National Park Service's (NPS's) approach to pest management. Prior to that time, the agency was using a system that required Washington Office approval before a pesticide could be used, but the agency's analytical approach to pest management was not as comprehensive and systematic as the one used by today's IPM practitioners. However, in 1979, President Jimmy Carter issued a memorandum which directed federal agencies to implement IPM whenever possible. For NPS, 1980 ushered in the formal adoption of IPM as a systematic approach to analyzing and solving pest problems. This adoption followed the successful IPM pilot program tried by the National Capital Region in 1979 (Sherald and DiSalvo 1987).

IPM is well known in NPS for reducing the use of higher-risk pesticides and the overall amount of pesticide use. However, it has also served to have agency personnel take a broader view of pest problems, within the context of ecological processes (Sherald and DiSalvo 1987). In effect, pests usually are understood to be symptoms of underlying problems that need to be solved. Once corrective measures are applied to the underlying problem, the symptom (i.e., the pest) is eliminated. Institutionalization of this approach has been fostered by the development of a week-long IPM course, along with various specialty courses, offered by senior program personnel beginning in 1980. To date, over 800 students have been trained in these courses, which are still being offered due to the need created by ongoing personnel transfers in NPS as well as the discovery of new information, with the subsequent development of new pest management methods.

One of the solid attributes of the IPM process is its utility in managing pests of every sort. Whether it is used to manage plants or animals, this approach works well whenever comprehensive analysis and up-to-date treatment prescriptions are needed. IPM also crosses boundaries in park management, as all disciplines are involved. The full participation of natural and cultural resource managers, line managers, and maintenance, curation, concessions, administration, and interpretation personnel is needed, sooner or later, to resolve pest problems in parks. Consensus building is a key to success!

Definitions

First, a pest is defined as an organism that interferes with the management objectives of a site. Second, IPM is defined as a decision-making process that serves to reduce risks created by pests and associated pest management strategies. IPM is the coordinated use of pest and environmental information with available pest management methods to prevent unacceptable levels of damage. This analysis is done on a case-by-case basis, so that treatment prescriptions are tailored to local conditions. It uses the most economical means, with the least possible hazard to

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people, property, and the environment. The goal of IPM is to manage pests and the environment so as to balance costs, benefits, public health, and environmental quality. IPM systems utilize a high quantity and quality of technical information about the pest and its interaction with the environment or site. Because IPM programs apply a holistic approach to pest management decision-making, they take advantage of all appropriate pest management tools, including, but not limited to, pesticides. Consequently, IPM is:

- A system which uses multiple methods to address both short and long-term pest management solutions.
- A decision-making process.
- A risk reduction system.
- Information intensive.
- Cost effective.
- Site specific (Currie 2001).

Based on the above, at a minimum a successful IPM plan consists of the following steps:

1. ***Identification of the organism.*** This step will determine what kind of action is needed, if any.
2. ***Consensus***. This involves defining the roles of the three types of people involved in the pest management equation (i.e., site occupant, pest manager, and decision-maker) to assure understanding and communication between them. If this step is omitted, failure is virtually guaranteed!
3. ***Management objectives***. The pest manager must determine the management objectives for a given site in order to solve the pest problem(s). This can be done by reviewing NPS policies and establishing priorities. A policy review includes determining if a species is native or exotic, locating the management zone, and evaluating the chances of successful management.
4. ***Set the action thresholds***. These are points when pest populations or environmental conditions indicate that action must be taken in order to prevent the pest population from crossing a pre-determined injury threshold; no action is taken until the threshold is reached.
5. ***Monitor***. This includes the site environment and the pest population. It should be done on a periodic, consistent basis to determine whether or not the action is effective.
6. ***Non-pesticidal action***. In this step, action is taken to modify the pest habitat to reduce the carrying capacity of the site, exclude the pest, or otherwise make the site's environment incompatible with the needs of the pest. This step, which involves applied ecology, is a critically important point.
7. ***Pesticidal action***. If non-pesticidal actions are not available or insufficient, approval is obtained to take appropriate pesticidal action. It should (a) use the least toxic, most effective, most efficient application technique that provides the longest dwell time in contact with the pest, (b) be applied when the pest is in its most vulnerable stage, and (c) carry the least possible hazard to people, property, and the environment.
8. ***Evaluate.*** This means checking the post-treatment results of the habitat modification or pesticide treatment actions by periodically monitoring the site and pest populations.
9. ***Records***. For each site, written records should be kept of pest management objectives, monitoring methods and data collected, actions taken, results obtained, and pesticides used.

All components of this system must be addressed and implemented in some form for it to be most effective. Deletion of portions of the system leads to greater and unnecessary dependence upon repeated pesticide treatments (Cacek 2001; Currie 2001).

Prevention

IPM practitioners realize that prevention plays a key role in holding down pest management costs. An initial investment measured in hours, days, or weeks per year may very well result in the prevention of infestations that could become measured in generations of effort and millions of acres of infestation. Examples of exotic pests in this category include yellow star thistle (infesting 20 million acres in the state of California alone), leafy spurge, saltcedar, various knapweed species, and purple loosestrife.

Inclusiveness

IPM is an ecological discipline that considers the use of all methods for immediate and long-term management. Although the classification of the methods may vary slightly by author, the available tools include, but are not limited to, the following:

- ***Educational measures***. This is a key element, for education creates understanding and promotes acceptance of needed actions. This has been done in many different ways, depending on the audience.
- ***Regulatory measures***. Examples are: the use of weed-free forage, fill, and mulch; inspections of horse trailers at entrance kiosks; and inspection of vehicles in campgrounds for gypsy moth egg masses.
- ***Planning***. This has a strong prevention aspect. One of the best examples is the multi-disciplinary team in the National Capital Region, which weighs options to select the best landscape materials for a given site.
- ***Cultural measures***. In general, these pertain to plant growth or how things are grown. It may also involve changing patterns of human behavior. One example is proper turf management (cultivar selection, aeration, fertilization, mowing height, appropriate irrigation, proper drainage, etc.). Crop rotation is an agricultural example.
- ***Physical measures***. This involves the installation of passive materials, or changes in the physical environment. Examples are the use of mortar, sheet metal, steel wool, and hardware cloth to exclude rodents from buildings.
- ***Mechanical measures***. This refers to the use of machinery to manage pests. Examples include deep plowing to destroy pupae in croplands, setting traps for rodents, etc.
- ***Biological measures***. This involves the use of living organisms to manage pests. The use of exotic species, and even some native species, as biocontrols of plants is regulated by the U.S. Animal and Plant Health Inspection Service (APHIS). APHIS issues both the importation and release permits. In line with the NPS 2001 management guidelines (NPS 2000), biocontrol agents proposed for use in the National Park System will be reviewed by the IPM program.
- ***Chemical measures***. This involves the application of pesticides to kill the target pest. "Pesticide" is a broad term. It includes insecticides, rodenticides, herbicides, fungicides, etc. Secondly, based on section 2(u) of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), pesticides are defined as "any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest." This also includes plant regulators, defoliants, and desiccants, among other things. In the case of NPS, the pesticide use proposal (PUP) system is used to provide oversight of all pesticides, except disinfectants.

- ***Genetic measures***. Genetic engineering is a new arena for the NPS's IPM program. It can involve the combination of genetic material from two entirely different organisms, such as "*Bt* corn," in which corn has been combined with the soil bacterium *Bacillus thuringiensis*, which produces an insect-killing toxin for phytophagous insects. In addition, some crops are being engineered to be "Roundup ready"; that is, herbicide-resistant crops ("Roundup" is a brand-name herbicide) can now be sprayed for emerged weeds, without injury. In the new NPS management policies (NPS 2000), it is indicated that designated IPM specialists will review the use of bio-engineered products in accordance with the as-yet unpublished NPS Director's Order 77-7.

Results

National pesticide usage. In the May 1977 environmental assessment for NPS's pest control program, the projected annual use of major pesticides for the 1976-1985 period was 222,900 pounds of active ingredient per year (NPS 1977). Analysis of actual use data for the 1983-1986 period showed that 25,000-40,000 pounds of active ingredient were being used per year. This translates into reductions of 82-89% per year under the projected level. Data from 1989 showed 34,636 pounds used (Savage 2001)—an 84% reduction. This happened despite the increase in the number of parks in (287 units in 1977; 378 in 1998) and the extent of (approximately 31,000,000 acres in 1977; 83,700,000 acres in 1998) the National Park System.

National trends. NPS tends to be ahead of the curve in the public sector. In fact, in the mid-1990s, Consumer's Union concluded that NPS has led federal agencies in the adoption of IPM (Benbrook et al. 1996). For example, simply by selecting lower toxicity materials we eliminated the indoor use of chlorpyrifos long before the Environmental Protection Agency banned some of its uses. We began using insect growth regulator bait stations for termites shortly after they reached the market in the mid-1990s. More toxic or environmentally mobile materials, such as the herbicides paraquat and atrazine, are not used. Scouting programs have been emphasized for our agricultural lessees. At Delaware Water Gap National Recreation Area, which has NPS's largest agricultural program, all the growers use scouting (Cacek 2001). Lastly, lower-risk materials are being increasingly emphasized, such as insecticidal soaps and horticultural oils. Two related points should be noted here. First, during the 1990s there was an evolution towards more of a balance between reducing pesticide use and seeking the most effective pest management available. Second, the amount of active ingredient may rise as we obtain more funding for vegetation management (Cacek 2001).

Park examples

Grand Canyon National Park. The park has many partners and has developed a very extensive volunteer program for exotic plant management, which has been experiencing significant growth. In 1997, for instance, 10,000 hours of volunteer time were logged. This contrasts with 2000, when 1,661 volunteers logged 16,174 hours of work. This is close to a 62% increase over a three-year span. Approximately 30 organizations help the park in this effort.

Park partners include the Sierra Club, Girl Scouts, Grand Canyon Association's Field Institute, Boy Scouts, Australia Trust, and many others. Volunteers help the park in many ways. They set up the nursery's drip irrigation system in the spring; they plant, mulch, water, collect, and process seed; survey for weeds; and hand-remove or spray exotic plants. In 2000, 17,460 Mediterranean sage plants were pulled from over 91 sites, 41,000 Russian thistle plants were pulled from 17 sites, and 1,130 diffuse knapweed plants were pulled. All told, plants of ten species were removed by hand from the park.

Support comes in other ways as well; collectively, they include 23 soft-money accounts, a complement of seasonal employees, and, in 2000, the work of 1,661 volunteers. It all adds up to a program that is making significant strides in reducing the Grand Canyon's exotic plant populations (Lori Makarick 2001).

Yellowstone National Park. The park has identified weed containment and partnerships as two especially critical parts of its exotic plant management program. To cite one case study, nine years ago a park volunteer mapped leafy spurge over a 4,000-acre tract on the Targhee National Forest. The survey revealed 17 relatively small infestations of leafy spurge, including one in the park. The Forest Service (USFS) site is within two miles of the park and has been subject to clearcutting, hunting, and other backcountry uses, so the Yellowstone staff was concerned that the leafy spurge infestation would spread into the park. Over the years, USFS has treated the tract once and NPS has treated the tract annually.

Another part of the story is that the park is also a member of the 1.5-million-acre Henry's Fork Weed Management Area (WMA). This includes Fremont County, Idaho; Teton County, Wyoming; Targhee National Forest; Yellowstone National Park; the Bureau of Reclamation; and four Idaho departments: Game and Fish, Transportation, Lands, and Recreation.

Because Yellowstone is a member of the WMA, the park was eligible to apply for a grant from the Idaho Department of Agriculture; $2,500 was obtained as a result. In addition, an $8,500 grant was obtained from the Greater Yellowstone Coordinating Committee. Consequently, the total of $11,000 will allow the park to re-survey the original 4,000 acres, plus an additional 6,000 acres, for weeds. The objectives will be to monitor the 4,000 acres for change and to do an initial assessment of the 6,000 acres.

The park has been making good progress on reducing the leafy spurge population. This can be seen by the decline in herbicide use. Initially, it took 9 gallons of spray mix to treat the population. This has declined to 2 gallons of mix, which is a 77.8% reduction. In addition, the nearest infestation is now a half-mile away from the park (McClure 2001).

Summary

IPM's decision-making process has been used successfully throughout the National Park System. It has provided a low-risk way to protect the visiting public, park staff, pesticide applicators, and the environment. Finally, since IPM is very information intensive, much of its success can be attributed to networking and partnering with academia, industry, non-governmental organizations, and other agencies.

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69 An approach to identifying "vital signs" of ecosystem health

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This paper presents an approach for scoping workshops to identify indicators of ecosystem health. This approach is based on systems concepts, and results in indicators that are clearly tied to a stressor-based model of the ecosystem. The approach is particularly designed to produce results that will be feasible for smaller parks, with relatively small staffs, to undertake.

This paper focuses on human-generated stressors. Discussion of the difference between these stressors and natural disturbances is beyond the scope of this paper and will be covered in a forthcoming paper, as will the concept of ecosystem health.

In addition to indicators of ecosystem health, a comprehensive program should also monitor those relevant to:

- Statutory requirements;
- "Primary" park resources for which the park was explicitly established;
- Resources that contribute to the visitor experience;
- Resources of particular interest to the public; and
- Issues of national or international concern.

Parameters in each of these five categories can be identified through means other than a scoping workshop. This paper focuses on identifying indicators of ecosystem health, in order to make the best use of the experts who attend a scoping workshop.

Systems concepts

Several characteristics of systems are relevant to identifying indicators of the health of an ecological system.

Hierarchy of scale. In the interconnections among the diverse components that compose a "middle-number system" such as an ecosystem, there is a hierarchy of scale. For example, a wetland system consists of components such as water, algae, amphibians, plants, and insects. The wetland system, in turn, is one component of a higher-scale system—a watershed (Figure 69.1).

Keystones. Interconnections within a system vary in their strength. "Dominant" species have a great effect on the structure and function of the ecosystem simply because they are so abundant. Other, less-abundant "keystone" species have an influence on the system that is far out of proportion to their abundance.

The keystone concept also applies at other levels of ecosystem scale (Southerland 1999). In some ecosystems there are keystone habitats. Desert springs are certainly a keystone habitat. In their absence, the desert ecosystem would be quite different. Estuaries have also been suggested as being keystone habitats.

Redundancy. The species in a guild may seem redundant in their function. However, each species is slightly different in its capabilities. These differences enable the function to continue in the ecosystem in spite of changing conditions. Rather than being redundant, the multiple species bring resilience to the system.

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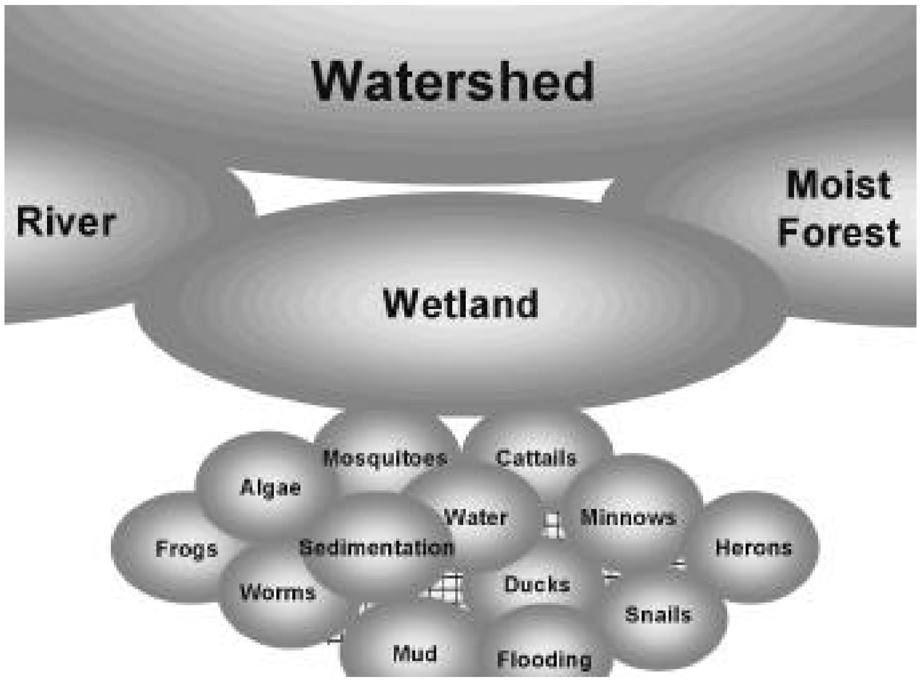

Figure 69.1. Illustrating the hierarchy of scale in an ecosystem. A wetland ecosystem consists of many diverse, interconnected components. At the next higher level of scale, the wetland along with a river system and adjacent forest system interconnect to form a watershed.

Some past monitoring programs have focused on species considered "representative" of a guild. Yet research has documented compensatory changes among species in a guild: as one species declines, others increase. In view of this, a monitoring program which assumes that one species is representative of others must rigorously test this assumption.

Organization and phase shifts. Systems are self-organizing through feedback loops that tend to damp change. These feedback loops can persist through a moderate degree of stress. As stress is increased, such as through loss of species or changing climatic conditions, there comes a threshold at which the feedback loops are no longer effective, and the system undergoes profound change, becoming a qualitatively different system.

Such "rollover" constitutes an essentially irreversible shift of the system to a new "stable state." Examples can be seen when acidic input exceeds a lake's buffering capacity, or when decades of fire suppression lead to a new system that is self-perpetuating.

The scoping workshop

Our approach to the identification of vital signs involves a three-day scoping workshop, involving at least a dozen experts from within and outside of the National Park Service (NPS). Participants represent a diverse range of multidisciplinary expertise. There are facilitated break-out sessions, involving at least two break-out groups. Each group intentionally has a mix of disciplines to help ensure an ecosystem approach that considers the interrelationships among ecosystem components and processes. Individual input is sought in ranking the resultant suggested indicators. Throughout the workshop, care is taken to avoid violating the Federal Advisory Committee Act.

The primary question addressed through the workshop is: How can we use knowledge of how stressor effects flow through the ecosystem to document whether the condition of the ecosystem is declining? The intent is to work on building a stressor-based conceptual model of the ecosystem. We recognize that models are developed with a specific use in mind, and a foodweb-based model may be very different from a stressor-based model. Our workshops begin to formulate a stressor-based model not as the *basis* for the discussions, but *through* the discussions.

Agents of change. The first step in the workshop process is for the park to identify tentative "agents of change" (Roman and Barrett 1999). While we have in the past referred to "visitors," "adjacent development," and "pollution," for example, as stressors, each of these in fact involves numerous stressors. Visitors, adjacent development, and pollution are, instead, agents of change that impose ecosystem-changing stressors.

Stressors. The next step of the workshop is to use the inter-disciplinary breakout groups to list specific stressors associated with each agent of change. For example, some stressors associated with the agent of change "visitors" are:

- Human presence;
- Litter;
- Sewage;
- Physical disturbance—trampling, erosion;
- Removal of things;
- Introduction of exotic species; and
- Water use.

Ecosystem effects. In the next step, the breakout groups brainstorm the ecosystem changes elicited by each stressor. A report of the U.S. Environmental Protection Agency (Southerland 1999) identified ten important ways in which human activities tend to affect ecosystems. Rapport (1992) and Costanza et al. (1992) suggested that this pattern of changes can be referred to as the "ecosystem distress syndrome."

1. *Habitats critical to ecological processes.* Loss of keystone habitats, such as desert springs, estuaries, and other "centers of organization" of the ecosystem.
2. *Pattern and connectivity of habitat patches.* Increased homogeneity across the landscape, with significantly larger patch sizes, loss of rare habitats, loss of connectivity among habitat patches, and no source of replenishment when local extinctions occur.
3. *Natural disturbance regime.* Alteration of natural disturbance regimes, such as fire, flood, and insect infestations; reduced ability to withstand stressors; higher levels of destruction from natural stressors, even when within their normal range of variability.
4. *Structural complexity.* Loss or reduction of components that create structural diversity, such as coarse woody debris in streams and downed trees; reduced structural complexity in riparian areas; breakage of the fragile edges on lava flows; and reduced complexity of micro-site structure.
5. *Hydrologic patterns.* Altered water chemistry, wider swings in water temperature, reduced infiltration, increased surface flow, wider swings in flow and increased "flashiness."
6. *Nutrient cycles.* Disruption of feedback loops that conserve and recycle nutrients, increased leaching of nutrients from the system, and alteration in the levels and normal patterns of variation of nutrients.

7. *Purification services.* Disruption of mechanisms by which the ecosystem breaks down wastes and detoxifies contaminants; addition of waste materials, toxics, acid, or other contaminants in amounts or at rates that exceed the capacity of the ecosystem to process them.
8. *Biotic interactions.* Reduced complexity of interactions among species; loss of specialized species, with generalist species making up a greater proportion of the biota; loss of narrow mutualist relationships; loss of species with vulnerable life histories, such as migratory species; replacement of perennial plants by annuals; increased homogeneity of life histories among the remaining species.
9. *Population dynamics.* Disruption of mechanisms that tend to damp down fluctuations in populations; increased "overpopulations," irruptions, and crashes.
10. *Genetic diversity.* Loss of certain genotypes; reduced genetic variation; increase in genetically based deformities and reproductive dysfunction.

Workshop participants are asked to keep these patterns in mind as they brainstorm the ecosystem effects elicited by each stressor.

In the example above, one stressor associated with the agent of change "visitors" was water use. In this particular instance, "water use" meant the withdrawal of water from an arid-land stream. Ecosystem changes resulting from this stressor may include:

- Reduced overall water flow;
- Loss of stream in dry years;
- Loss of fish;
- Altered aquatic invertebrate community;
- Altered riparian plant structure;
- Altered stream temperature patterns;
- Altered riparian bird community;
- Altered riparian invertebrate community;
- Altered soil characteristics; and
- Altered soil water-holding capacity

These include not only direct effects, but also indirect ones—secondary, tertiary, and beyond—elicited by the stressor.

"Cascading effects." Workshop participants are then asked to examine linkages among these stressor effects and identify the flows of stressor effects through the ecosystem. This represents the beginning of a stressor-based conceptual model of the ecosystem. Figure 69.2 illustrates how the effects of the stressor "water withdrawal from an arid-land stream" cascade through the ecosystem.

Monitoring questions. Monitoring questions are specific questions, derived from the conceptual ecosystem model, concerning specific ecosystem effects and stressors. These monitoring questions will be the basis for establishing measurable indicators. Examples of monitoring questions from the example above are:

- How much of the stream's water is being withdrawn, relative to its flow?
- Is the stream becoming ephemeral?
- Are vulnerable amphibians declining?
- Is the structure of riparian plant communities changing?
- Is the stream water becoming warmer?
- Are specialized riparian bird species declining?

These monitoring questions clearly reflect the ten key types of effects identified by Southerland (1999). They illustrate how this approach leads to a monitoring program that will address the ecological system much more fully than would a program that focuses solely on the populations of various plant and animal species.

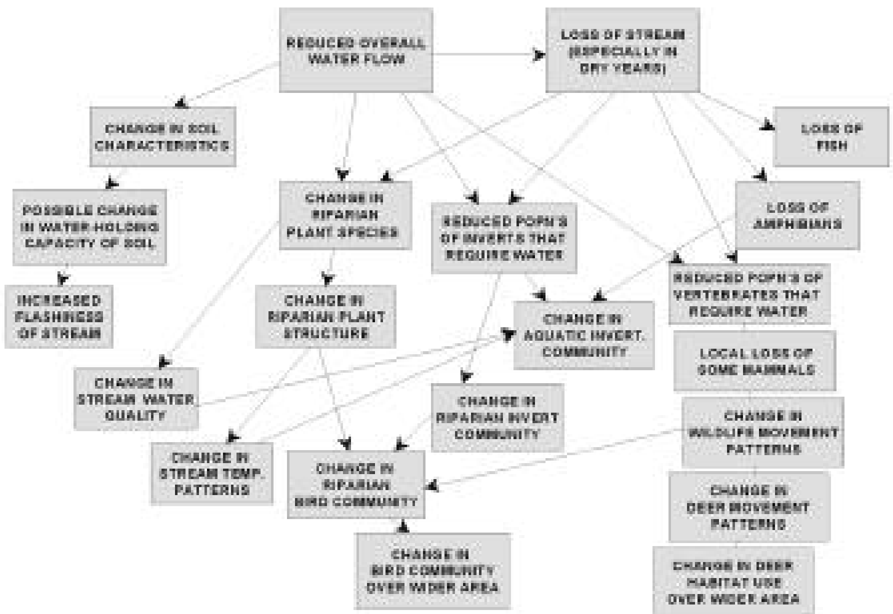

Figure 69.2. Illustration of the cascading flow of ecosystem effects elicited by the stressor "water withdrawal from an arid-land stream."

Propose indicators. In considering possible indicators, it is important to recognize three categories of indicators:

- *Stressor indicators* are measures of the stressor itself, such as the amount of water pollution or air pollution emitted by a source. A drawback of measuring the stressor itself is that there is no indication of the ecosystem consequences.
- *Exposure indicators* are measures of the amount of stressor to which the ecosystem is exposed, such as the concentration of water pollutants in a stream
- *Response indicators* are measures of changes that occur in the ecosystem, such as genetically based deformities in amphibians. A drawback of response indicators is that they do not provide clear evidence of the cause (O'Laughlin et al. 1994).

The type of indicator selected should be a conscious decision, giving consideration to the strengths and weaknesses of each type in a given situation.

Some indicators are *diagnostic,* specific to a given stressor. They can be used in monitoring focused on a known or suspected stressor. Other indicators are *non-diagnostic* (similar to blood pressure in humans), reflecting the "ecosystem distress syndrome" and changes that tend to be elicited by many types of stressors in all types of ecosystems (Council of Great Lakes Research Managers 1991).

Some indicators may be better at providing early warning, while others are retrospective, providing evidence of ecosystem change after the change has occurred. The Council of Great Lakes Research Managers (1991) suggested that the best early-warning indicators tend to be non-diagnostic. Diagnostic indicators, on the other hand, tend to be more retrospective (Figure 69.3).

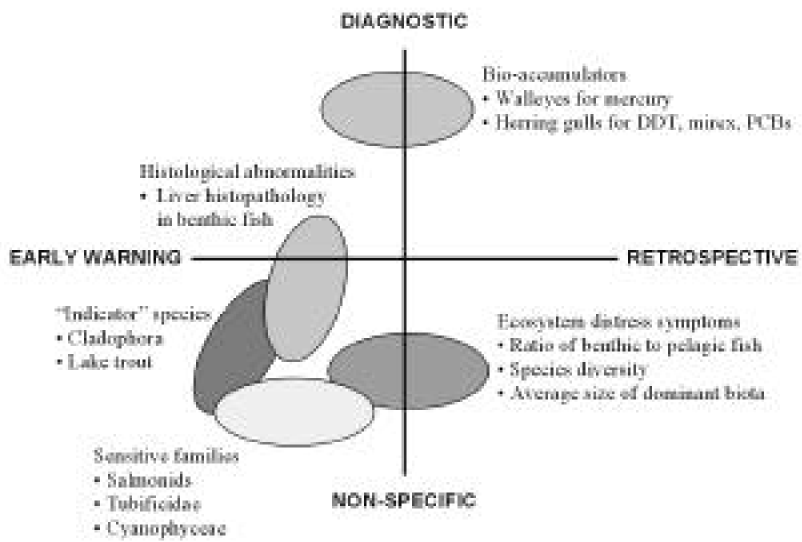

Figure 69.3. Relationship between the early warning vs. retrospective quality of indicators, and whether they are diagnostic or non-diagnostic. From Council of Great Lakes Research Managers 1991.

As Olympic National Park has noted, where there is a known stressor of concern, indicator selection is based on the predicted response of the ecosystem to that stressor. For stressors that are not yet recognized, but which may occur now or in the future, indicator selection focuses on early-warning non-diagnostic indicators of ecosystem health. Stressor- or issue-specific monitoring may be shorter-term, while early-warning monitoring is likely to be long term. A comprehensive monitoring program should include a combination of relatively short-term stressor-specific monitoring and long-term ecosystem-health monitoring to provide an early warning of changes.

In the workshop, each participant is asked to individually select a stressor and associated ecosystem response, develop a monitoring question, and propose a measurable indicator. It is suggested that each participant do this five times, proposing five indicators.

In the example we've been following, with the stressor "withdrawal of water from an arid-land stream," proposed indicators might include the following:

- Duration and timing of low flow;
- Volume diverted vs. stream volume;
- Areal extent of riparian habitat;
- Riparian canopy coverage at the overstory, middle-story, and understory levels;
- Composition and relative abundance of nesting riparian bird species;
- Trout population size;
- Frog population size;
- Composition and relative abundance of aquatic macroinvertebrate species;

- Population index of aquatic mollusks; and
- Deer population within one mile of the stream.

Ranking indicators. The next step of the process is for the participants to individually rank the indicators. Ranking criteria may include:

- Ecological significance of the ecosystem change being measured;
- Management significance of the stressor;
- Urgency, or vulnerability to essentially irreversible change; and
- One or more criteria reflecting the quality of the indicator.

Each of these criteria is rated on a scale of 1 to 5, with 5 representing the greatest significance, urgency, or quality. The intent is not to produce a total score for each indicator, but to provide feedback to the park on the significance, urgency, and quality of each indicator.

Scores are compiled and the results presented to the park for its use in selecting candidate indicators. The park should also review the stressors and ecosystem effects to ensure that significant ones were not omitted simply because no one happened to propose an indicator for them.

Many authors have presented their thoughts on what makes for a high-quality indicator (for example, Hinds 1984; Council of Great Lakes Research Managers 1991; Cairns et al. 1993; Trame and Tazik 1995; Lewis et al. 1996; McRae et al. 1996; Herlihy et al. 1997; Pankhurst 1997; Summers et al. 1997; Woodward et al. 1999). Characteristics of an ideal indicator include its being:

- Based on the conceptual model;
- Clearly connected to the function it reflects;
- At an appropriate scale;
- Anticipatory;
- Timely;
- Broadly applicable to many stressors (for early-warning indicators);
- Sensitive to the stressor (for diagnostic indicators);
- Measurable;
- Constant during the period of measurement;
- Easy to measure;
- Non-destructive to measure;
- Robust;
- Unique; and
- Socially appealing.

In addition, the ideal indicator will have a high "signal-to-noise" ratio, known variability and other statistical properties, and the capacity to be communicated to managers and the public.

Suggest methodologies. In the final step of the workshop, each participant is asked to provide information on possible methodologies, literature citations, names of authoritative experts, and other information relevant to each of the indicators.

Conclusion

As a result of this workshop, the park has a list of potential indicators of ecosystem health, each with a clear connection to a stressor-based conceptual model of the ecosystem. The park has feedback on the significance and quality of each indicator, which can be used in narrowing the list to a relatively small number of the most important indicators. While even this amount of monitoring, or the technical expertise required, may be beyond the capability of a park with a small staff, this gives the park some direction in seeking technical assistance to further develop its monitoring program.

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70 Simulation of long-term monitoring sample designs in Denali National Park

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Introduction

A park-wide sampling strategy for the long-term ecological monitoring (LTEM) program for Denali National Park and Preserve is presently in the design stages. The goal of this monitoring program is to watch various ecological resources in the park to better understanding the current status of the resource and direction of trends. Part of the design process for the Denali monitoring project involves discussions of appropriate sampling designs for various resources. For vegetation resources, several sample designs have been discussed among project participants, including stratified random sampling and systematic sampling. In the course of these discussions, questions have arisen regarding the feasibility and accuracy of the systematic sampling approach applied over an area as large as Denali.

In this paper we explore some of the questions surrounding systematic sampling of the park by presenting the results of a computer exercise designed to mimic vegetation sampling in the park. In this exercise, we construct a realistic representation of a vegetation parameter (basal area of white spruce, *Picea glauca)* over the entire park and sample that parameter using a systematic grid of points. Once this hypothetical population of basal area is sampled, statistical estimators for the total and mean of the parameter are computed, and the sampling is repeated. In the end, this computer exercise allows us to draw conclusions about the statistical validity and accuracy of the systematic sample design by summarizing the variance and bias of our estimators. We also investigate grid spacing and its effects on variance and bias of the estimators.

Methods

Our goal was to construct a reasonably realistic representation of a sampling scheme, and replicate it a large number of times to verify and assess the design's statistical properties. Long-run averages, bias, and variances of proposed estimators could be assessed in this simulation because true underlying quantities were known. We choose to focus our simulation efforts on a single vegetation resource, basal area of white spruce, because it is an important attribute of the vegetation structure in the park, and because some information on basal area in Denali was known. Basal area was also indicative of a large number of variables present in the park because it exhibited typical patterns in its distribution.

Our simulation to assess properties of a systematic sample design can be outlined as follows: (1) a reasonably realistic map of basal area for the entire park was constructed, (2) the map of basal area was sampled using a randomly placed systematic

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grid, (3) sample estimates were computed and stored, (4) steps 2 and 3 were repeated a large number of times, and (5) bias, variance, and confidence interval coverage was computed. Details of each step follow.

Step 1 — Construction of the basal area map

A grid of 2,355,882 points, spaced 100 m x 100 m apart and large enough to span the park, was defined. For purposes of the simulation, artificial basal area values were assigned to each point in this 100-m x 100-m grid. Artificial basal area values were assigned to each location by randomly sampling from a *mixture distribution* that was chosen to approximate the perceived distribution of basal area in the park. These mixture distributions appear in Figure 70.1. The general mixture distribution shape was bi-modal, with one mode near zero and another at larger values. The relative size and placement of each mode varied according to elevation and slope. Once generated, this grid of 2.35 million locations and associated basal area values was viewed as the sample *universe* or "truth." Expected values of sample quantities (computed during the simulation) were compared to "true" basal area quantities of this map.

Step 2 — Simulated sampling

Sample grids of various sizes were defined and randomly placed over the larger 100-m x 100-m grid of basal area constructed in step 1. At each sample location, basal area was noted and the resulting list of basal areas values from all grid points constituted one sample. Sample grid spacings were 20 km, 17.5 km, 15 km, 12.5 km, 10 km, 7.5 km, 5 km, 3.5 km, and 2 km. Due to irregularities in the border of Denali National Park, the number of sample grid points inside the park border varied across random placements of the sample grid.

Step 3 — Sample calculations

Sample quantities of interest were calculated for each random placement of the sample grid. Let the number of points in the 100-m x 100-m basal area map defined in step 1 be N (*population size*). Let the number of points that fell inside the boundary of the park from the ***i***-th random placement of the sample grid defined in step 2 be n_i *(sample size)*. Let x_{ij} be the ***j***-th basal area value of the grid sample obtained from the ***i***-th random placement of the sample grid. For each random grid placement (i = 1, …, 500), mean basal area was estimated as:

$$\bar{x}_i = \sum_{j=1}^{n_i} x_{ij} / n_i \, .$$

The estimated standard error of mean basal area was computed as:

$$s_i = \sqrt{\left(\frac{N - n_i}{N}\right) \frac{\sum_{j=1}^{n_i} (x_{ij} - \bar{x}_i)^2}{n_i - 1}} \, .$$

A 95% confidence interval for the true basal area was computed as:

$\bar{x}_i \pm 1.96 s_i$.

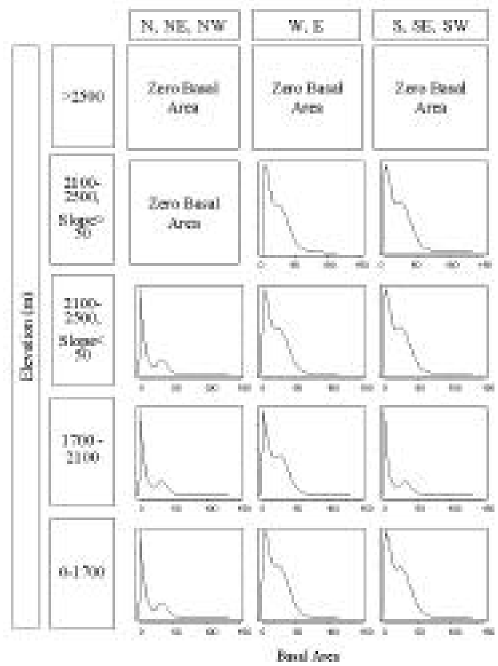

Figure 70.1. Mixture distribution used to generate basal area values in the Denali sampling simulation. Vertical axes plot relative frequency.

Step 4 — Iteration

Steps 2 and 3 were repeated 500 times. Each repeat of steps 2 and 3 defined a single *iteration* of the simulation. Sample quantities from each iteration (step 3) were stored for later summarization.

Step 5 — Summarization

Bias, variance, and *root mean squared error (RMSE)* were assessed for all sample quantities of interest. Let μ represent the true average basal area on the 100-m x 100-m map defined during step 1. Let

$$\bar{x}_. = \sum_{i=1}^{500} \bar{x}_i / 500$$

and

$$s_{\bar{x}}{}^2 = \sum_{i=1}^{500} (\bar{x}_i - \bar{x}_.)^2 / 499$$

be the simulated expected value and variance of the mean basal area estimator. The expected value and standard error of the variance estimate were:

$$s_. = \sum_{i=1}^{500} s_i / 500$$

and

$$s_s{}^2 = \sum_{i=1}^{500} (s_i - s_.)^2 / 499 \, .$$

Bias in the estimator of mean basal area was computed as:

$$b = \bar{x}_. - \mu \, .$$

Estimated *RMSE* of mean basal area was calculated as:

$$RMSE_x = \sqrt{b^2 + s_{\bar{x}}{}^2} \, .$$

Bias in the estimate of variance was computed as:

$$b_s = s_. - \sqrt{s_{\bar{x}}{}^2} \, ,$$

and the *RMSE* of the standard error estimator was:

$$RMSE_s = \sqrt{b_s{}^2 + s_s{}^2} \, .$$

Coefficients of variation (CV) for both the estimators and observed sample size were computed as the standard deviation divided by expected value. For example, CV of the mean estimator was computed as:

$$\sqrt{s_{\bar{x}}{}^2} / \bar{x}_. \, .$$

Coverage of the sample confidence interval was computed as the proportion of confidence intervals (out of 500) that contained the true mean basal area. Coverage of the confidence interval was:

$$c = \sum_{i=1}^{500} I_i / 500$$

where I_i was an indicator function that took on a value of 1 if the confidence interval from iteration i contained the true mean, and 0 otherwise. Theory holds that c should equal 0.95 for confidence intervals with nominal coverage of 95%.

Lower values of *RMSE* were considered better than higher values of because *RMSE* is a function of both variance and bias. For example, an unbiased estimator with large variance might have *RMSE* equal to a biased estimator with small variance. Prior to simulation, it was acknowledged that *RMSE* generally decreases as sample size increases, but it was of particular interest to note whether a large gain in *RMSE* was obtained by any one grid spacing. If so, this grid spacing would be considered for implementation. Confidence interval coverage was assessed the same way as *RMSE*. It was of interest to note whether or not a large improvement in confidence interval coverage was obtained by a single grid spacing.

Results

The average number of grid points inside Denali was 53.8 for the 20-km grid, 74.4 for the 17.5-km grid, 102.5 for the 15-km grid , 143.7 for the 12.5-km grid, 227.2 for the 10-km grid, 414.8 for the 7.5-km grid, 930.5 for the 5-km grid, 1915.9 for the 3.5-km grid, and 5868.7 for the 2.5-km grid. The standard error of sample size as a function of grid size is plotted in Figure 70.2. Variability in sample size ranged from 15 for the 2.5-km grid to 2 for the 20-km grid. The CV of sample size (i.e., average sample size divided by its standard error) ranged from 0.2% for the 2.5-km grid to 3.7% for the 20-km grid.

Bias and standard error of both the mean and standard error estimator is plotted in Figure 70.3. Bias in both the mean and standard error estimator was small for all sizes of grids. *RMSE* for both the mean and standard error estimators are plotted in Figure 70.4. *RMSE* of both estimators increased as grid size increased and as sample size decreased. No large gains, or “jumps,” in performance of either estimator were apparent as grid size increased. CV of the mean estimator was remarkably small even for smaller sample sizes. CV of the mean estimator for the 20-km grid was 12.3%. CVs for denser grids were all less than 11%.

Coverage of the 95% confidence intervals is plotted as a function of grid size in Figure 70.5. Coverage of the confidence intervals ranged from 0.93 to 0.97, with average coverage across grids equal to 0.948.

Conclusions

The systematic sample design proved to be a useful design for sampling the artificial population constructed here. Bias in the estimate of mean basal area was negligible and variation in the estimator was relatively small for all grids. Coverage of the sample confidence intervals was adequate for all grid sizes. The resources required to sample the park were relatively constant and predictable because variation in the number of sample points was less than 4% for all grid sizes. We hypothesize that use of a systematic grid in a real study of Denali National Park and Preserve would yield highly accurate and precise estimates of white spruce basal area and other parameters that behave similarly to basal area.

No obvious “jumps” in precision of the mean estimator were evident that might aid choice of a particular grid size. The plot displayed in Figure 70.4(b) shows a very slight “break” in the *RMSE* of the standard error estimator between the 5- and 7.5-km grids, and between the 12.5- and 15-km grids; however, these breaks are not prominent enough to influence large-scale management decisions. Choice of a particular grid spacing for a real study of Denali will likely rely heavily on logistic and budgetary considerations.

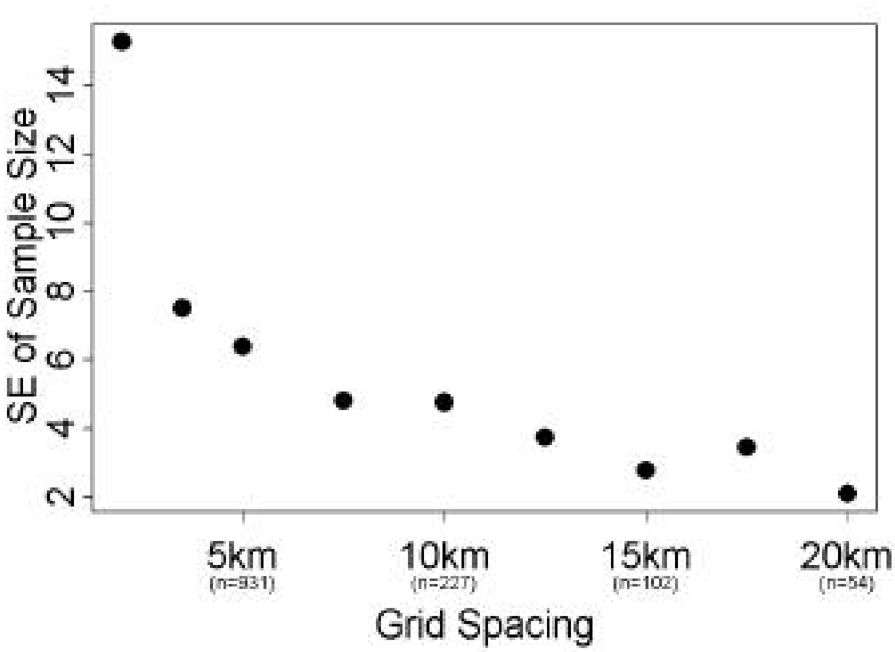

Figure 70.2. Variability of observed sample size (n) as a function of grid size.

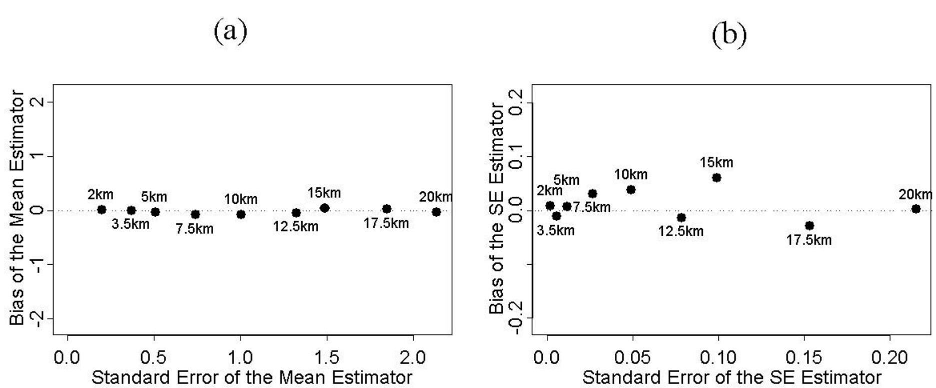

Figure 70.3. Bias and standard error of the mean (a) and standard error (b) estimators. Point labels denote sample grid spacing. RSME is distance from the origin to each point.

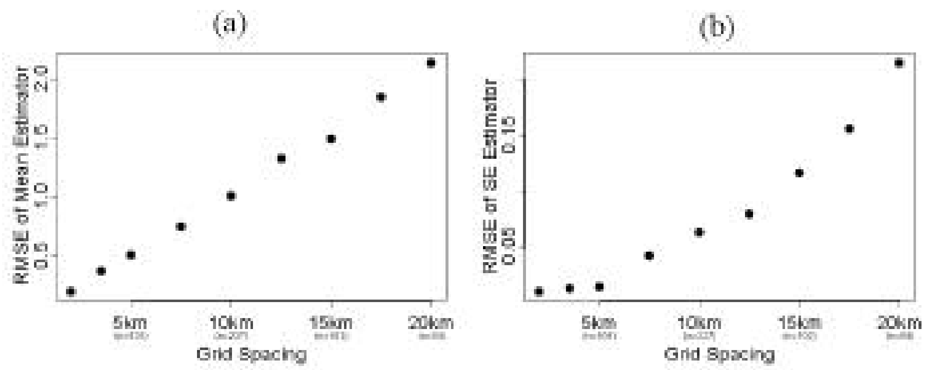

Figure 70.4. RMSE of the mean (a) and standard error (b) estimators as a function of grid size.

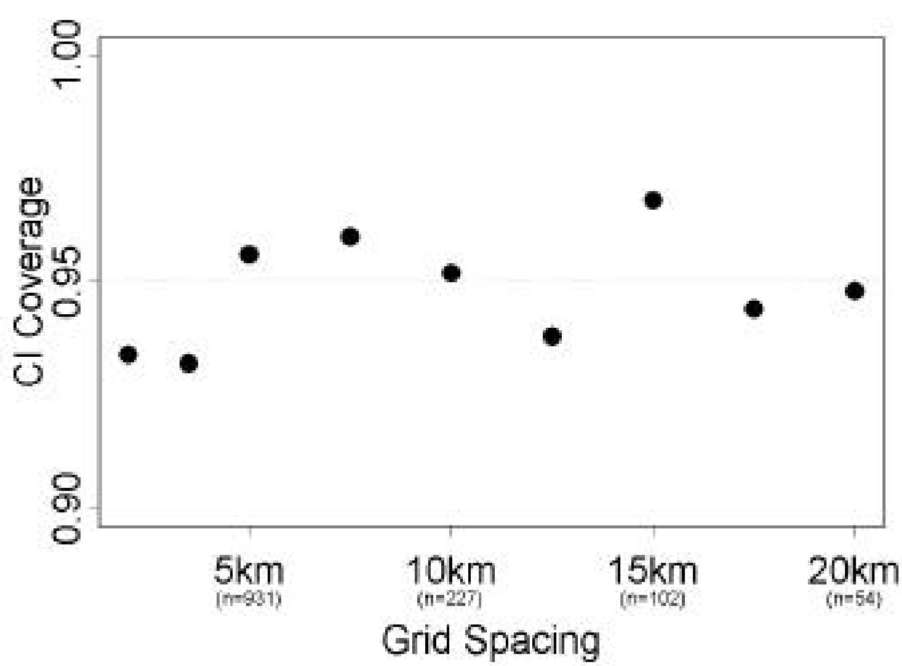

Figure 70.5. Estimates of confidence interval coverage as a function of grid size.

The results of this simulation apply to estimation of the parkwide mean of a parameter that behaves like basal area. Performance of a systematic grid for other parameters that do not behave like basal area remains unknown. Performance of the grid is also unknown for non-mean estimators such as regression, analysis of variance, principal components, etc. In addition, if estimates of the mean are sought for subsections of the park, precision (i.e., variance) will likely suffer due to reduced sample sizes in those regions.

71 Recommended features of protocols for long-term ecological monitoring

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In 1991, the National Park Service (NPS) selected seven parks to serve as prototypes for development of a long-term ecological monitoring program. Denali National Park and Preserve was one of the prototype parks selected. The principal focus of this national program was to detect and document resource changes and to understand the forces driving those changes. One of the major tasks of each prototype park was to develop monitoring protocols. In this paper, we discuss some lessons learned and what we believe to be the most important features of protocols.

One of the many lessons we have learned is that monitoring protocols vary greatly in content and format. This variation leads to confusion about what information protocols should contain and how they should be formatted. Problems we have observed in existing protocols include (1) not providing enough detail, (2) omitting critical topics (such as data management), and (3) mixing explanation with instructions. Once written, protocols often sit on the shelf to collect dust, allowing methods changes to occur without being adequately considered, tested, or documented. Because a lengthy and costly research effort is often needed to develop protocols, a vision of what the final product should look like is helpful. Based on our involvement with the prototype monitoring program for Denali (Oakley and Boudreau 2000), we recommend key features of protocols, including a scheme for linking protocols to data in the data management system and for tracking protocol revisions. A protocol system is crucial for producing long-term data sets of known quality that meet program objectives.

What is a protocol?

According to the American Heritage dictionary, a protocol is "the plan for a medical or scientific experiment." Often, the term "protocol" is used in a narrower sense to refer to specific field or laboratory methods for data collection or measurement. We prefer the broader definition that a protocol is a complete study plan—not just a description of field or laboratory methods. A study plan explains what will be done and why. As a complete study plan, a protocol should demonstrate that the proposed monitoring has worthwhile objectives achievable for the given ecosystem within the limits of time, money, and personnel available for the project.

Why are protocols so important in long-term monitoring?

Long-term monitoring faces challenges not evident in the typical 2- to 5-year research project. Measurement error and consistency are of much greater concern. To be confident that any change detected is the result of an actual change, and that changes are not masked by inconsistent methods, one must know the data were collected with repeatable and documented methods. The quality of the data must be

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known. The many subtleties in the collection, handling, and analysis of data may affect their future use. These subtleties need to be documented to provide future data users with the information they need to evaluate data quality.

Sources of measurement inconsistency include:

1. Changes in measurement techniques, often due to improvements in technology;
2. Changes in personnel (a given in any long-term monitoring program);
3. Changes in what is being measured (e.g., dropping one attribute in favor of another);
4. Changes in the location where measurements are taken (e.g., the National Weather Service station at Denali park headquarters has been moved several times in its 75-year history, each move resulting in a recognizable change in the data); and
5. Changes in the frequency and timing of measurement (Beard et al. 1999).

Measurement errors are much easier and less costly to prevent than to correct (Geoghegan et al. 1990; Beard et al. 1999). The key to preventing such errors is to have a quality assurance and quality control plan (Shampine 1993). The heart of any such plan is a detailed statement of the methods to be used, and a documentation of the methods actually used (Geoghegan 1996).

Protocols written in the context of long-term ecological monitoring need more background information and greater attention to detail than is the case for the typical research project (Geoghegan 1996). Moreover, monitoring protocols need to be stored in a manner that keeps track of changes, and allows the exact methods used in any given year to be easily reconstructed.

Who are protocols written for?

In writing any document, one must consider the audience: the needs of the audience determine content, format, and style. Audiences for monitoring protocols are diverse, and include both current and future:

- Monitoring program managers;
- Peer reviewers;
- Monitoring personnel—the people who do the work; and
- Scientists who are hoping to use the data.

We want to emphasize that the audience includes people in the future. The success of the monitoring program depends on our ability to communicate exactly what must be done so that measurements taken by different observers at different and widely separated points in time prove consistent and comparable. We must also communicate why it is important to continue such measurements, or the opportunity costs of monitoring may exceed its perceived value, resulting in program disruption or termination (Caughlan and Oakley, in prep.). The diversity of the audience for monitoring protocols, including managers, scientists, and technical workers, creates a challenging situation for the protocol writer.

Recommended features of protocols

To meet the specific requirements of protocols for long-term monitoring, we recommend that they be divided into three distinct parts: (1) a narrative, (2) standard operating procedures (SOPs), and (3) a revision tracking system. The narrative explains in general terms what will be done, and why. Attached to the narrative will be any number of SOPs. SOPs are instructions written for the personnel doing the monitoring work; formatting—to optimize readability—is advised (Wieringa et al. 1998). The revision tracking system consists of a process for approving methods changes, a log to record and easily retrieve information about any changes made, and use of the monitoring database to link protocols and data.

What goes in the narrative?

The narrative provides contextual information and is a clarifying document for all protocol audiences. The narrative is especially helpful to the program manager concerned with overall program relevancy and logistical coordination. The narrative should describe:

- Objectives, including explicit information on how they relate to overall program goals. Objectives should be measurable (e.g., What magnitude and direction of change in a given attribute is of interest? At what scales of space and time? What degree of confidence is required?).
- The sampling design and rationale for its selection.
- The measurements to be taken. The details, however, will be provided in the SOPs.
- Data quality objectives and quality controls required to meet those objectives.
- How data will be organized, documented, analyzed and reported.
- Budget information and an indication of what measurements will be taken and what methods would be used under varying budget scenarios.
- A schedule.
- Documentation of required compliance measures (e.g., Animal Use and Welfare Committee approval).
- The history of the protocol's development.

The narrative concludes with a list or flow chart referencing all the SOPs written to describe the monitoring work. The narrative should also explain assumptions about who will use each procedure. Procedures should be written at a level of detail appropriate for the intended users. The relationship between staffing decisions, the level of detail in the procedures, and the depth of training is important, and should also be explained in the narrative.

Standard operating procedures

Every protocol can be expected to include several SOPs. One step in protocol development will be to decide how to divide the work into logical units that cover all aspects. As an example, the protocol for small-mammal population monitoring at Denali is broken into 13 SOPs:

- SOP 1—Before the field season;
- SOP 2—Field season schedule;
- SOP 3—Field crew training;
- SOP 4—Setting up a small-mammal sampling grid;
- SOP 5—Catching and processing small mammals;
- SOP 6—Data management;
- SOP 7—Data analysis;
- SOP 8—Reporting;
- SOP 9—Working in the backcountry;
- SOP 10—Processing of incidental mortalities;
- SOP 11—Documenting vegetative and site characteristics of sampling grids;
- SOP 12—End of field season; and
- SOP 13—Procedure for changing the procedures.

Procedures are instructions, and they must be geared specifically to the intended user. Wieringa et al. (1998) provide a thorough overview of procedure writing. They note that the attention of the person who will use the instructions is divided: he or she is trying to perform a task while following the written guidance. Thus, formatting the SOP to improve readability under the worst conditions of expected use is helpful. The instructions should be written as steps with appropriate use of placeholders, emphasis, and organization. A benefit of writing procedures as steps is that it becomes clearer where missteps are most likely, and where quality control checks should therefore be inserted. Numbering of steps helps by providing a convenient way to track revisions.

The publication format of procedures will vary depending on the type of work to be performed. If the procedures will be used outdoors, a conveniently sized handbook with waterproof pages might be appropriate. For lab procedures, a more standard publication format could be used. To ensure that the publication format helps the intended user operate in a consistent manner, testing under actual conditions of use is essential.

While the primary audience of the SOPs is monitoring personnel, the SOPs will also be used by peer reviewers and future scientists interested in the data. These audiences will be concerned with the fine details of how data were collected.

Revision tracking system

In any long-term monitoring program, methods will change over the years. New technologies may appear, allowing data to be collected more efficiently. Reconstructing the exact methods used in any one year can be difficult or impossible. Yet, without knowing what methods were used in a given year, we diminish or lose the use of that data for comparisons. Although stability in methods is desired, it is wiser to plan in advance for changes by using a procedure for approving changes (changes should not be made lightly) and keeping track of changes. In some cases, data will need to be collected under both the old and new methods for a period of time to allow calibration and build confidence that the data will not be compromised by the change in methods (Newell and Morrison 1993; Beard et al. 1999).

We recommend that three features be included in a revision tracking system. The first is to have a procedure that addresses how procedural changes will be made and approved (e.g., SOP 13 in the Denali small-mammal protocol). The second is to keep a revision history log that tracks changes as they occur. The log provides an index to the changes, including when they were made, why they were made, and what the exact change was. The third is to use the monitoring database to connect the data collected via a protocol to the protocol itself. To do this, each version of the protocol receives a code. The code is entered into a “protocol” field in the database with the data collected as per the protocol. The protocol codes can also be linked to a digital copy of the protocol, which is also stored in the database. This system for documenting the methods used will allow future users of the data to readily ascertain whether comparable methods were used. This system of tracking protocol changes and which protocols were used in a given year will need to be planned for and kept in mind as the protocols are written, and as the database management system for a monitoring program is developed.

Discussion

The monitoring program development process focuses on producing protocols that, when properly used, allow data to be collected, analyzed, and reported in a way that meets the program’s goal. Protocols represent the end product of what may have been a lengthy, convoluted, and expensive development and testing process. Capturing this protocol development history within the protocol itself is important. The appropriate place for this is the narrative. Peer review of the protocol is critical before they are officially sanctioned. For peer reviewers to evaluate whether the draft protocol will meet the objectives, they will need to see the results of pilot studies, any sensitivity modeling that occurred, and other background information. Thus, while the SOPs, as instructions, would not include data, the narrative needs to include, or refer to, data collected and analyzed in the process of protocol development. These data need to be available for peer reviewers looking at the adequacy of the protocol for meeting the stated objectives.

The protocol development history should also include information about methods that were considered or tested but rejected. The reasons such methods were rejected are important to understanding what methods eventually were adopted. A promising technique may have been overlooked or rejected based on faulty reasoning. Peer reviewers and future monitoring program managers will need to evaluate these contingencies. In addition, problems that prevented use of a certain technique at one point in time may later be overcome, perhaps by technological developments or increased funding, leading to a change in methods. As noted, such changes need to be carefully evaluated prior to adoption. Understanding the full history of the protocol's development will be critical to such evaluations.

Conclusion

Writing protocols as full study plans to the level of detail we recommend will require more effort than is typically devoted to such activities in short-term research. However, without clear statements of methods and the rationale for using them, or records of what methods were actually used, the quality of the data will be unknown, and the ability of a monitoring program to achieve its goal diminished. Substantial work is required to develop and test monitoring methods to ensure they will be consistent and comparable over periods ranging from decades to centuries. To fully realize the investment in the monitoring program, protocols must meet this higher standard.

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72 Expanding single-species monitoring toward system management: an example from Santa Barbara Island, California

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Introduction

For over a decade, the National Park Service (NPS) has conducted annual monitoring of vegetation, seabirds, landbirds, terrestrial vertebrates, and weather on Santa Barbara Island in Channel Islands National Park. We are now able with some confidence to define the normal range of variation for these ecosystem elements. Consequently, we should be prepared to take action, if only to increase our observations, if population numbers or other indexes diverge drastically from these levels. Additionally, several of the protocols for monitoring have undergone peer review and are being or have already been modified to reflect recommended changes to the program.

Our challenge now is to use the data from these somewhat disjunct monitoring programs to understand more thoroughly the processes and levels of tolerance within island ecosystems. Our natural systems should ultimately be the resource with which we as land managers are concerned, and in the future should be the unit at which we direct our preservation and management efforts. In too many cases the lack of understanding of system processes and ecological relationships within systems has allowed us to take incorrect actions or no actions at all towards the preservation of resources within parks (Blaustein 1993; McAuliffe 1996; Coonan et al. 1998).

Santa Barbara Island is one of the smallest and, arguably ,the simplest of the island systems within Channel Islands National Park. The island is 2.6 sq km in size, and supports only two terrestrial vertebrate species. The vegetation communities contain a mixture of grass and shrublands, and eight community types have been identified (Hochberg et al. 1979). The most dynamic component of the island's ecology is the assemblage of seabirds which utilize the island for roosting and nesting during the spring and summer seasons. During this period, thousands of birds, including California brown pelicans *(Pelecanus occidentalis californicus),* western gulls *(Larus occidentalis),* Xantus' murrelets *(Synthliboramphus hypoleucus),* and others will be found across the island.

The only terrestrial mammal on the island is a subspecies of deer mouse, *Peromyscus maniculatus elusus*. This species has been monitored for approximately 15 years, both by NPS since 1992, and by several researchers during the 1970s and 1980s (Collins et al. 1979 for a summary; Drost 1989; Drost and Fellers 1991). For many years it was noted that the numbers of mice on Santa Barbara Island were often extremely high, and it was suggested by some that land cover alterations caused by the introduction of non-native plant species might be the cause of these artificially high numbers. If so, the presence of so many mice on Santa Barbara Island might be having negative effects on native plants and seabirds that would not be seen in the system were mice present at levels similar to those to which these other groups have evolved.

The park is currently compiling mouse data from park islands for trend analysis (Schwemm and Coonan, in draft). Beginning with Santa Barbara Island, we have

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begun to relate these data to those from other monitoring programs to identify the most significant driving processes within the system, and to answer some specific questions regarding relationships between deer mice and some of these other groups.

In this paper we examine two of the theories that have implicated mice as a threat to native species on Santa Barbara Island, and use monitoring data to determine whether or not relationships exist. The first involves predation by mice on the eggs of Xantus' murrelets, a small, cliff-nesting seabird. As part of the seabird monitoring program, biologists record the number of eggs laid, as well as the fate of the eggs. Evidence from egg-shell fragments is used to determine whether eggs have hatched, have been abandoned, or have been preyed upon by mice. Several researchers have stated that predation by mice is a significant threat to productivity for Xantus' murrelets on Santa Barbara Island (Murray et al. 1983; McChesney 1995; McChesney et al. 2000).

We also looked at the relationship between mouse numbers and productivity of *Coreopsis gigantea*, a native shrub which was decimated by non-native animals and fires on Santa Barbara Island during the last century. Mice directly prey on the stems of *Coreopsis*, particularly in late summer and fall when the somewhat succulent nature of the plant provides water. It is unknown whether or not mice prefer *Coreopsis* seeds over other seeds, but if so it has been suggested that, between the effects of granivory and direct predation, unusually high numbers of mice may be having significant negative effects on the recovery of *Coreopsis* on the island (Salas 1990).

Methods

Deer mouse monitoring is conducted in spring and fall on two sampling grids, one in *Coreopsis* habitat and one in habitat dominated by exotic grasses. Resulting data analysis provides population and density estimates, along with general trend information regarding sex ratios, reproductive effort, and average weights (Fellers et al. 1988; Figure 72.1). We compared mouse densities with levels of murrelet egg predation and productivity as measured by the seabird monitoring program (Lewis et al. 1988). When comparing mouse densities and predation rates of murrelet eggs, we used only spring mouse densities since eggs are only present during that time.

Vegetation monitoring is conducted using line-intercept methodology, in which the species and height is recorded for every plant that touches a designated point (Halvorson et al. 1988). *Coreopsis* predation is not directly measured, so we looked at the number of total hits of *Coreopsis* on three specific transects and as averaged over all island transects as indicators of trends in *Coreopsis* productivity.

Because weather data collection from Santa Barbara Island has been sporadic, weather data from Santa Catalina Island, 40 km to the east, was used for analysis.

Results

Mouse densities fluctuated seasonally and in multi-annual cycles of approximately three to four years (Channel Islands National Park terrestrial vertebrate monitoring data; Schwemm 1995; Schwemm 1996; Austin 1996; Austin 1998). The highest density recorded since 1985 was 666 per ha in the fall of 1993 on the *Coreopsis* grid. The lowest was in the spring of 1999 on the grassland grid, when one individual was caught twice. (In several cases when captures were extremely low, an estimate of 10 per ha was included in the final data analysis to indicate that some animals, albeit only a few, were present. There was never an instance when no animals were captured.) When compared over all years, numbers of mice were significantly higher on the *Coreopsis* grid than on the grassland grid ($t = 3.129$, $p = .007$, $n = 16$). The greatest within-year increase in density occurred on the *Coreopsis* grid in 1993, when the estimate rose from 42 per ha in the spring to 666 per ha in the fall. There was no correlation between within-year spring and fall densities.

Murrelet productivity, as measured by eggs hatched per nest attempt, ranged from 0.5 in 1992 to 1.3 in 2000. However, in only three of the last 18 years was productivity greater than 1.0. The average number of eggs lost to predation within the two colonies ranged from over 70% to less than 20%. In 14 of 17 years, predation rates were greater within the Cat Canyon colony (Channel Islands National Park seabird monitoring data; Ingram and Carter 1997; Martin and Sydeman 1998; Martin 2000). We found no correlation between mouse densities and egg predation, although the sample size was small (n = 7). There is a general negative effect of egg predation on productivity, suggesting that mice are having detrimental effects on the murrelet population.

Figure 72.1. Weighing a deer mouse on a hand-held scale.

Spring mouse densities were correlated with the total number of hits on vegetation transects the previous spring ($r^2 = 24.9$, $f = 4.97$, $p = 0.042$). A postulated relationship between fall mouse densities and total hits on *Coreopsis* on the vegetation transect closest to the *Coreopsis* mouse grid was not significant ($r^2 = 48.5$, $f = 4.71$, $p = 0.082$). No other significant relationships were found between mouse densities and any measure of vegetation, including natives versus non-natives, life form, or species.

There was a significant correlation between previous winter rains and mouse densities during the following spring ($r^2 = 78.2$, $f = 17.910$, $p = 0.008$), and a slight but significant negative correlation between winter rains and current spring mouse densities ($r^2 = 26.3$, $f = 6.41$, $p = 0.021$).

Discussion

Mouse densities on Santa Barbara Island routinely reach extremely high numbers. Data from the monitoring program combined with historical observations suggest that this is the normal condition of the population on this island. Many studies have suggested that island populations of *P. maniculatus* and other species of small mammals occur generally in higher densities in island habitats (Redfield 1976; Sullivan

1977; Gliwicz 1980) and are less aggressive than mainland populations (Halpin and Sullivan 1978; Halpin 1981). These authors suggest that densities are maintained in greater numbers on islands to prevent extinction in an environment to which there would be no recolonization, and that the increased tolerance by individuals to conspecifics is likely an adaptation to this situation (Halpin and Sullivan 1978; Adler and Levins 1994). While monitoring data do not provide direct measurements of such factors, indirect measurements of behavior and dispersal might be sufficient to examine more closely how the ecology of the deer mouse population on Santa Barbara Island may reflect responses to an insular ecosystem (Schwemm and Coonan, in draft).

It does not appear that mice have a negative effect on productivity of *Coreopsis*, as might be suggested by observations of the damage mice can inflict on individual plants. We examined data from three vegetation transects in *Coreopsis* habitat, and found the total number of hits on those transects to be stable or increasing. Anecdotally, botanists on the island have noticed a substantial increase in the number of seedlings and overall recruitment of *Coreopsis* over the last decade (D. Rodriguez 2001; Junak et al. 1993). These seedlings may or may not be the cause of the overall increase in *Coreopsis* hits (older plants increasing in size may also be responsible), but the existing data and observations suggest that the species appears to be increasing in abundance on the island. This evidence does not support the hypothesis that large areas of exotic grasslands on the island are supporting mouse densities at artificially high levels. Because *Coreopsis* habitat appears to provide superior habitat for mice over grasslands, it may be that as the island recovers from previous impacts and *Coreopsis* distribution continues to increase, mouse numbers island-wide will actually rise.

Finally, it appears that regardless of the number of mice present on the island during the spring, the amount of predation by mice on murrelet eggs will generally be high. Even if mouse densities are low, a certain number of individuals will apparently travel the necessary distance to obtain eggs. If mouse numbers are not artificially high, it is possible that this level of egg predation is normal, and that the birds have evolved strategies to meet this threat. In this scenario, the birds would be successful as a group, despite these high levels of predation. However, murrelets are not currently meeting levels of productivity that will sustain the species (Sydeman et al. 1996). If mouse predation is a normal process in the ecology of the two species, other off-island factors may be working to affect the success of the birds (Carter et al. 2000).

Conclusion

Data from four monitoring programs on Santa Barbara Island are beginning to provide information which describes a system regulated in large measure by seasonal rains. Varying amounts of winter precipitation result in changes in annual vegetative productivity, which in turn affect mouse population dynamics for the following year. This relationship is not linear, however, and even moderate levels of plant productivity apparently provide a food source sufficient enough to allow mice to reproduce continually throughout the summer and fall. We suggest that mouse productivity is limited by significant food shortages, severity of winter weather, and natural mortality.

Eggs appear to be the most preferred food, and mice are apparently driven to take murrelet eggs at levels great enough to affect bird productivity regardless of levels of plant productivity. Changes in weather regimes or other processes that may alter the relative frequency of specific plant species or groups of species do not appear to result in corresponding changes in mouse numbers or egg predation.

These results are of importance for two current management issues. First, the productivity of Xantus' murrelets appears to be decreasing throughout their range (Sydeman et al. 1996), and the bird may soon be proposed for federal listing as a species of concern. Several authors have identified the greatest threat to birds on land as predation by terrestrial rodents, and some type of snap-trapping or direct reduction strategy might be necessary to protect birds during the nesting season. Although this is not a desirable alternative, the monitoring data strongly indicate that the mouse population on the island would not suffer any long-term impacts from such a temporary, localized loss of individuals. The park will look very closely at any proposal to protect the birds that includes killing mice, and data from the monitoring programs will certainly be included in any analysis of potential impacts.

Secondly, an effort beginning this fall to eliminate black rats from Anacapa Island will almost certainly result in the loss of all mice from treated areas (Howald 2001). Mitigation measures for mice include the capture and holding of mice during the treatment, followed by a post-treatment release, most likely in the spring. Data from the deer mouse monitoring program on Santa Barbara and Anacapa islands are being used to develop this mitigation strategy, and to determine methodologies for release protocols. For example, since Xantus' murrelets also nest on Anacapa Island, one aspect of our release strategy may be to hold the animals until after the murrelet nesting period. Alternatively, mice could be re-introduced only to interior areas of the island, where they will be less likely to reach shoreline cliffs and murrelet nests before the eggs have hatched.

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