Winter 2011–2012 • Volume 28 • Number 3 www.nature.nps.gov/ParkScience

PARKScience

Integrating Research and Resource Management in the National Parks

National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science
Office of Education and Outreach

WILDERNESS STEWARDSHIP AND SCIENCE

We reflect on the vitality of the Wilderness Act, the utility of recent and classical wilderness research findings, and the application of scientific tools for stewardship of these special landscapes

In This Issue

PARKScience
Integrating Research and Resource Management in the National Parks

Volume 28 • Number 3 • Winter 2011–2012
www.nature.nps.gov/ParkScience
ISSN 0735–9462

Published by
U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science
Office of Education and Outreach
Lakewood, Colorado

Director, National Park Service
Jon Jarvis

Associate Director, Natural Resource Stewardship and Science
Bert Frost

Editor
Jeff Selleck

Guest Editors
Wade M. Vagias, PhD (wade_vagias@nps.gov)
Management Assistant, Yellowstone National Park

Ingrid E. Schneider, PhD (ingridss@umn.edu)
Professor, Department of Forest Resources and
Director, Tourism Center, University of Minnesota

Copyeditor/Proofreader
Lori D. Kranz (contractor)

Layout
Jeff Selleck

Editorial board
John Dennis—Deputy Chief Scientist, Natural Resource Stewardship and Science

Rick Jones—Interpretive Planner, Harpers Ferry Center

Bob Krumenaker—Superintendent, Apostle Islands National Lakeshore

Charles Roman—NPS Research Coordinator, North Atlantic Coast Cooperative Ecosystem Studies Unit, University of Rhode Island

Bobbi Simpson—Supervisory Biologist and California Exotic Plant Management Team Liaison, Point Reyes National Seashore

Kathy Tonnessen—NPS Research Coordinator, Rocky Mountains Cooperative Ecosystem Studies Unit, University of Montana

Editorial office
Jeff Selleck
National Park Service
NRSS/OEO
P.O. Box 25287
Denver, CO 80225-0287

E-mail: jeff_selleck@nps.gov
Phone: 303-969-2147
Fax: 303-987-6704

Sample style for article citation
Landres, P., W. M. Vagias, and S. Stutzman. 2012. Using wilderness character to improve wilderness stewardship. Park Science 28(3):44–48.

Printed on recycled paper.

Continued on page 4 >>

From the Editors

Why wilderness?

What is it about wilderness that intrigues us and engages our hearts and minds? Is it that wilderness represents some of the least manipulated ecosystems on Earth, landscapes that provide safe harbor for vast ecological systems and processes? Is it that wilderness provides a scientific baseline, particularly for research that seeks to advance our understanding of the effects of human activities on natural systems? Perhaps it is because wilderness is a portal to earlier, primitive cultures or that it provides a respite from the stressors of modern life for contemporary humans. Indeed wilderness represents a special place in the American psyche, simultaneously place and idea, fact and emotion. We explore several of these values and purposes in this issue of *Park Science*.

The National Wilderness Preservation System was created with passage of the Wilderness Act in 1964. As of 2011 it consists of 757 wilderness areas, covering nearly 110 million acres (45 million ha), in 45 states, administered by four bureaus: the U.S. Department of Agriculture's Forest Service and the Department of the Interior's Bureau of Land Management, U.S. Fish and Wildlife Service, and National Park Service. The National Park Service plays an especially important role in wilderness stewardship because it stewards more than 40% of this area, or 44 million acres (18 million ha), comprising 60 designated wilderness areas in 49 national parks. From the swamps of the Marjory Stoneman Douglas Wilderness in Florida's Everglades National Park to the ice-encrusted peaks of Alaska's Gates of the Arctic Wilderness in Gates of the Arctic National Park and Preserve, the portfolio of NPS-administered wilderness is vast, irreplaceable, and imminently important.

Just as significant as the wilderness landscape is the need for effective stewardship of wilderness. Like National Park System management, wilderness stewardship encompasses a wide array of issues, opportunities, and challenges; however, wilderness character and legislative protection afford it an additional layer of complexity. This issue of *Park Science* highlights this concept, with contributions from representatives from government, academia, and nongovernmental organizations.

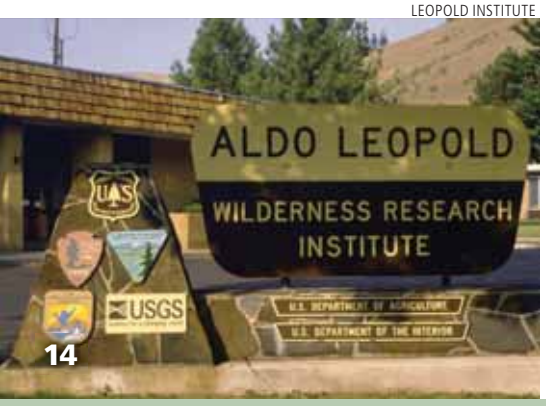
In developing this edition we sought to put forth articles, case studies, invited features, and commentaries that demonstrate the breadth and depth of wilderness science and stewardship and the role wilderness plays in the portfolio of NPS-administered lands. The many contributors investigated effective stewardship of these areas and offer perspectives on policy, program evolution, and optimal wilderness management. The authors synopsize 50 years of wilderness visitor research; highlight climate change, transboundary cooperation, consequences of fire suppression, and wilderness as a cultural landscape; and discuss better alignment of science and research in a manner consistent with the Wilderness Act. Altogether, this edition seeks to celebrate the wilderness we know and inspire its future successful stewardship. For as Aldo Leopold said, "The richest values of wilderness lie not in the days of Daniel Boone, nor even in the present, but rather in the future."

We extend a heartfelt thank-you to all who contributed to this issue and to all those who help steward wilderness.

—Wade M. Vagias and Ingrid E. Schneider, Guest Editors
Jeff Selleck, Editor

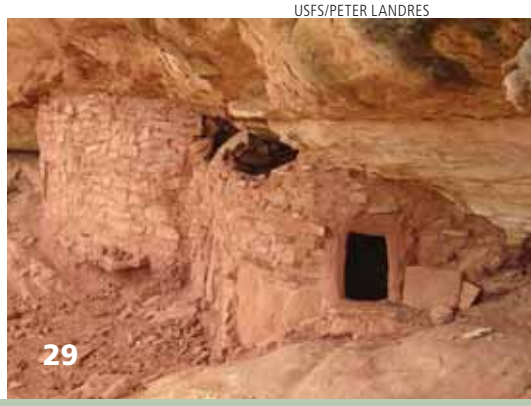
Contents

LEOPOLD INSTITUTE



COPYRIGHT VANCE MARTIN

USFS/PETER LANDRES



DEPARTMENTS

ON THE COVER

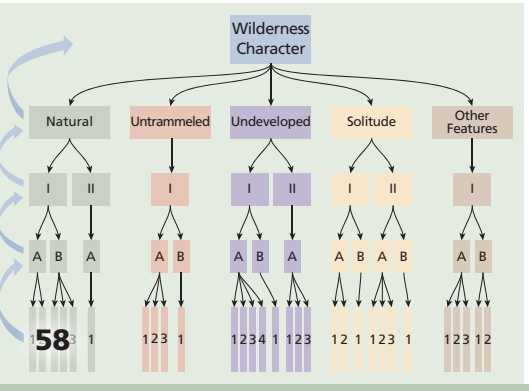
To capture this image of Cascade Pass in the Stephen Mather Wilderness, North Cascades National Park, Washington, Keith Brumund-Smith scrambled to the top of the highest peak in the area as the sun was setting. The photographer returned to his campsite guided by full moon and headlamp. This photo was a runner-up in the recent *Park Science* wilderness photo contest. For more winning shots of wilderness see pages 7–11, 42–43, and 66.

NPS/KEITH BRUMUND-SMITH

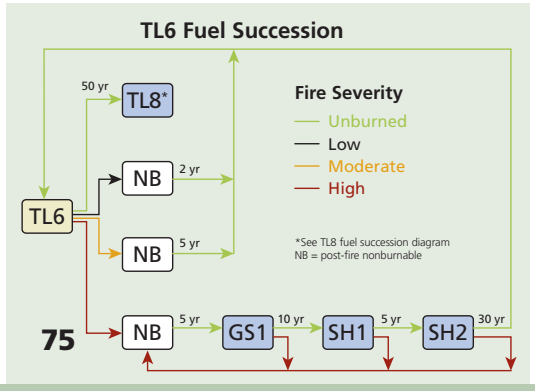
PROFILE

INVITED FEATURES

IN FOCUS: WILDERNESS CHARACTER



JEFF MARION



>> Masthead (continued from page 2)

Park Science is a research and resource management bulletin of the U.S. National Park Service. It reports the implications of recent and ongoing natural and social science and related cultural research for park planning, management, and policy. Seasonal issues are published usually in spring and fall, with a thematic issue that explores a topic in depth published annually in summer or winter. The publication serves a broad audience of national park and protected area managers and scientists and provides public outreach. It is funded by the Associate Director for Natural Resource Stewardship and Science.

Articles are field-oriented accounts of applied research and resource management topics that are presented in nontechnical language. They translate scientific findings into usable knowledge for park planning and the development of sound management practices for natural resources and visitor enjoyment. The editor and board review content for clarity, completeness, usefulness, scientific and technical soundness, and relevance to NPS policy.

Article inquiries, submissions, and comments should be directed to the editor by e-mail; hard-copy materials should be forwarded to the editorial office. Letters addressing scientific or factual content are welcome and may be edited for length, clarity, and tone.

Facts and views expressed in *Park Science* are those of the authors and do not necessarily reflect opinions or policies of the National Park Service. Mention of trade names or commercial products does not constitute an endorsement or recommendation by the National Park Service.

Park Science is published online at http://www.nature.nps.gov/ParkScience (ISSN 1090-9966). The Web site provides guidelines for article submission, an editorial style guide, an archive and key word searching of back issues, and information on how to subscribe or update your subscription.

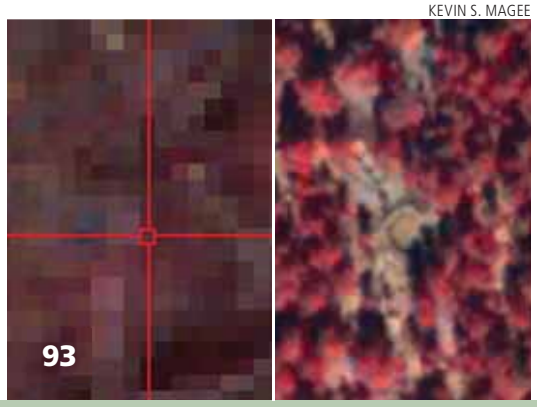
Though subscriptions are offered free of charge, voluntary donations help defray production costs. A typical donation is $15 per year. Checks should be made payable to the National Park Service and sent to the editorial office address.

IN FOCUS: WILDERNESS CHARACTER (CONT'D)

CONTRIBUTED ARTICLES

NPS PHOTO

KEVIN S. MAGEE



NPS/LIZ BALLENGER

UPCOMING ISSUES*

Spring 2012
Seasonal issue. May Release.
In production.

Fall 2012
Seasonal issue. October release.
Contributor's deadline: 1 June.

Winter 2012–2013
Seasonal issue. January 2013 release.
Contributor's deadline: 15 October.

Visit http://www.nature.nps.gov/ParkScience for author guidelines or contact the editor (jeff_selleck@nps.gov or 303-969-2147) to discuss proposals and needs for upcoming issues.

*Production of three theme issues in 2011 precluded publication of the fall 2011 issue as originally planned. This issue will be combined with and released as the spring 2012 edition.

PARK SCIENCE ONLINE

www.nature.nps.gov/ParkScience/

- Complete catalog of back issues, with key word searching
- Author guidelines
- Editorial style guide
- Share comments on articles
- Manage your subscription

CONTRIBUTED ARTICLES (CONT'D)

CONCLUSION

In This Issue

NATIONAL PARKS, WILDERNESS AREAS, AND OTHER PROTECTED AREAS DISCUSSED IN THIS ISSUE

Abbreviations

IPP	International Peace Park
NF	National Forest
NHP	National Historical Park
NL	National Lakeshore
NM	National Monument
NP	National Park
NPP	National Park and Preserve
NR	National River
NRA	National Recreation Area
NS	National Seashore
NWR	National Wildlife Refuge
W	Wilderness

Index

A Wilderness Celebration

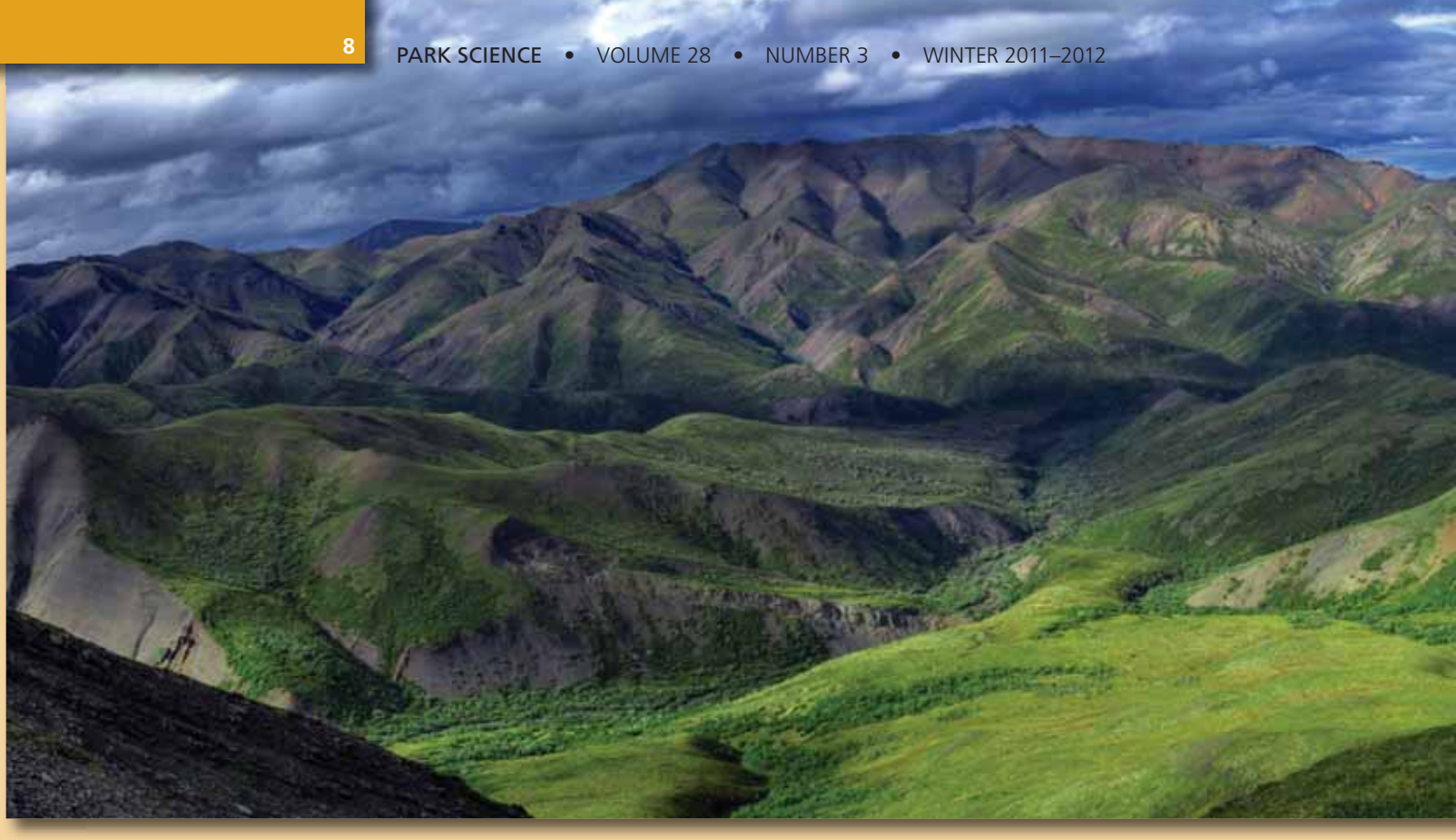
The photographs on the cover, in this section, and interspersed in articles throughout this issue are selections from the Park Science *wilderness photo contest, held in September 2011. The event garnered 131 entries, with 8 winners and 10 runners-up. We congratulate the winners and thank all participants whose love of wilderness generated such a glorious response.*

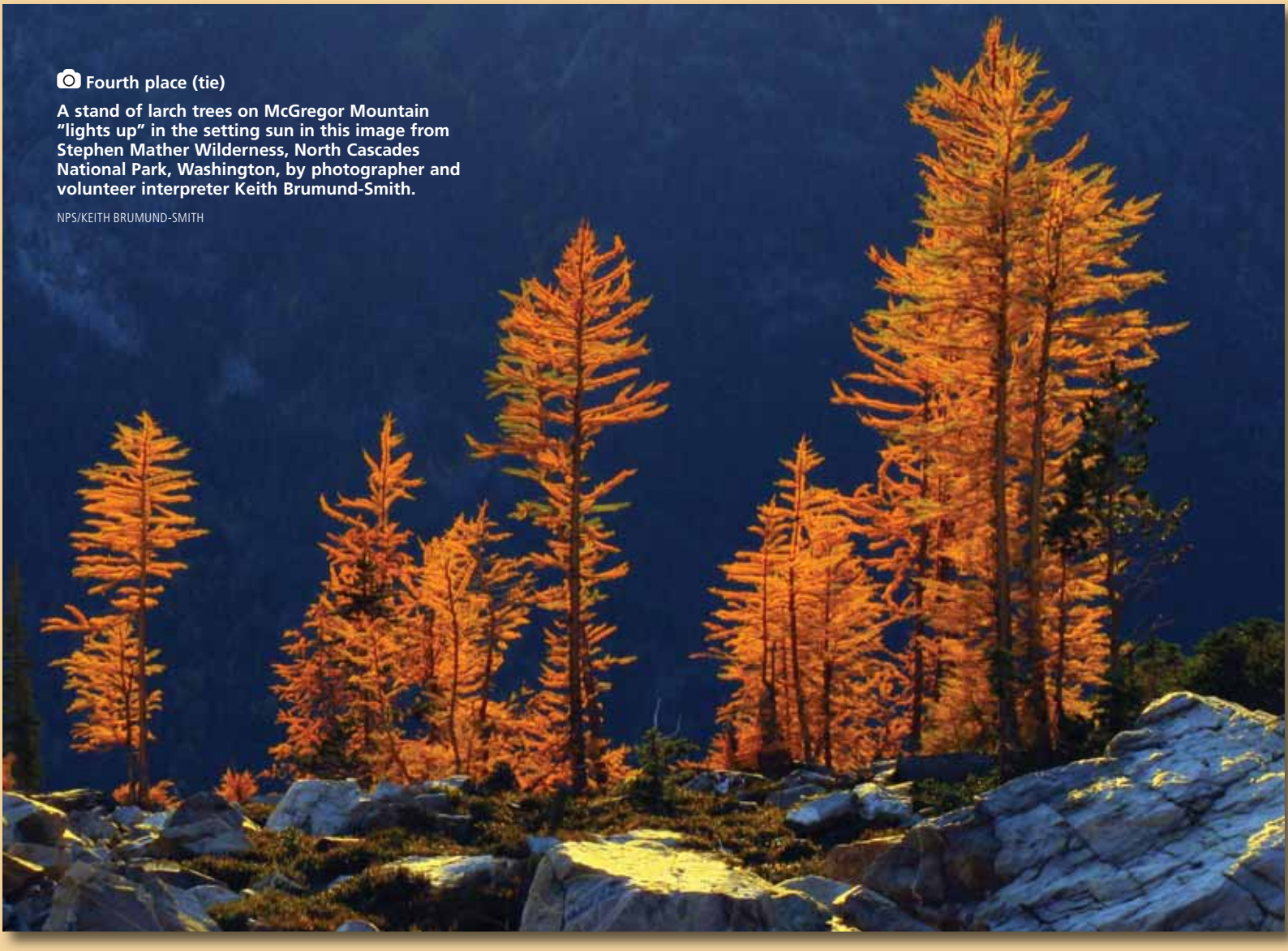
Contest photos in this issue are distinguished by a camera icon (📷). A slide show of all entries can be viewed online at http://www.nature.nps.gov/ParkScience/graphics/vol_28_3/PhotoContest/index.html. Individual photos are available for downloading from NPS Focus, the digital library and research station, at http://npsfocus.nps.gov/npshome.do?searchtype=npshome. Search for "Park Science 2011 Wilderness Photo Contest."

📷 **Third place (tie)**

Biologist and photographer Alicia Burtner notes that relatively few visitors venture below the canyon rim to experience the magnificence of the Grand Canyon, Arizona. Though not designated as a wilderness area, the Grand Canyon is proposed as wilderness and managed under policy to preserve wilderness character.

NPS/ALICIA BURTNER

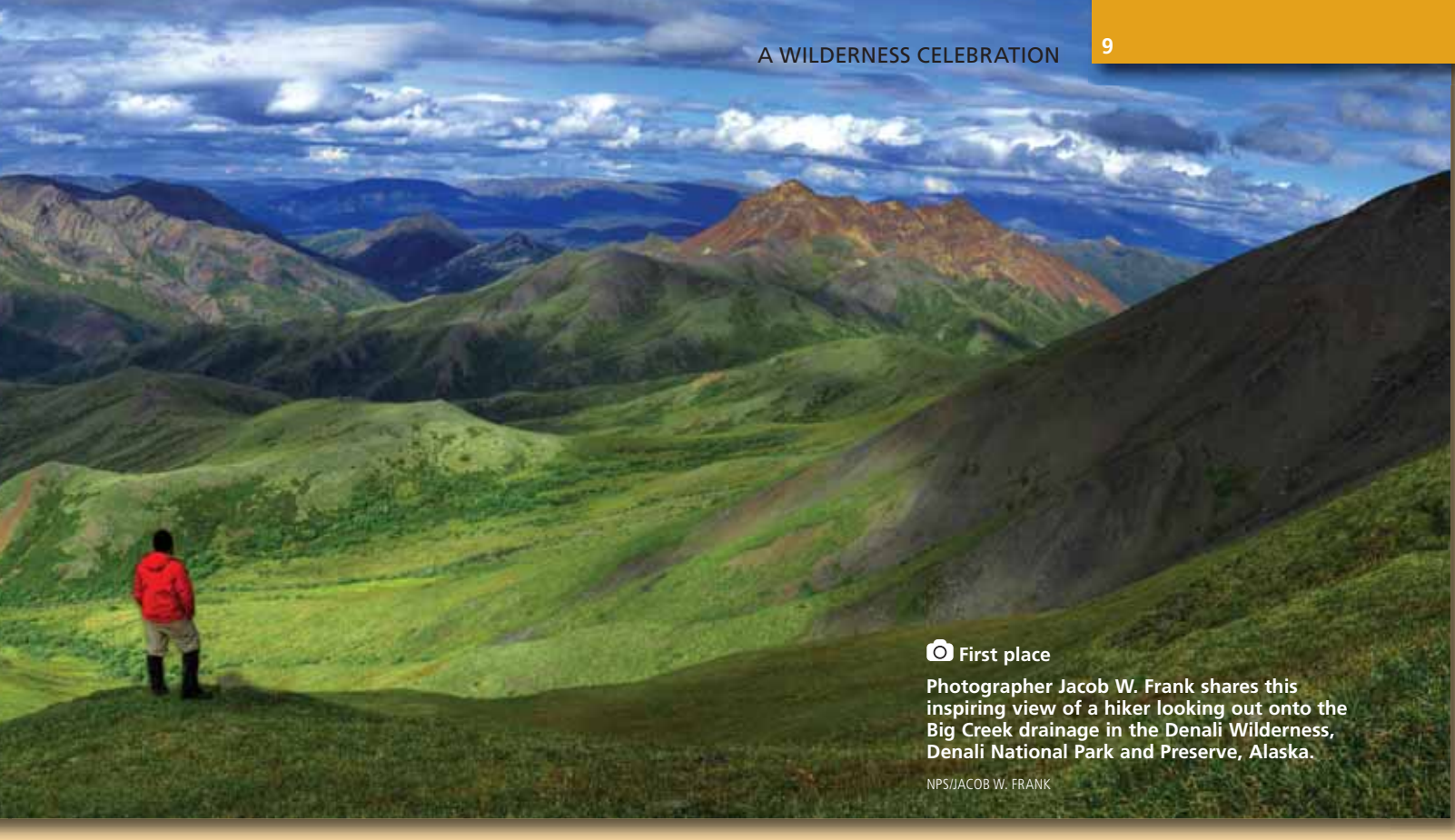




Fourth place (tie)

A stand of larch trees on McGregor Mountain "lights up" in the setting sun in this image from Stephen Mather Wilderness, North Cascades National Park, Washington, by photographer and volunteer interpreter Keith Brumund-Smith.

NPS/KEITH BRUMUND-SMITH



First place

Photographer Jacob W. Frank shares this inspiring view of a hiker looking out onto the Big Creek drainage in the Denali Wilderness, Denali National Park and Preserve, Alaska.

NPS/JACOB W. FRANK

Second place (tie)

Photographer Doug Buehler notes that the combined effects of weather, season, and time of day create a range of moods on El Capitan, the most recognizable feature of the Guadalupe Mountains Wilderness, Guadalupe Mountains National Park, Texas.

NPS/DOUG BUEHLER

(Above, left) Second place (tie)

Botanist Jane Cipra captures dramatic light on Eureka Dunes in Death Valley Wilderness, California. Formerly an off-road vehicle playground, the dunes are habitat for two threatened plant species and five rare beetles.

NPS/JANE CIPRA

(Above, right) Runner-up

Ecologist Chris Sergeant documents a Steller sea lion haul-out near South Marble Island, Glacier Bay Wilderness, Alaska. On a calm day you can hear the din of sea lions from miles away.

NPS/CHRIS SERGEANT

(Right) Fifth place

Photographer Matt Melcher awaits his turn to ascend the Half Dome cables in Yosemite Wilderness, California, about 45 minutes before sunrise.

NPS/MATT MELCHER

Runner-up

A hiker atop Divide Mountain in Denali Wilderness, Alaska, takes in the panorama, which includes the headwaters of the west fork of the Toklat River.

NPS/JACOB W. FRANK

(Above, left) Runner-up

Photographer Molly Hanna depicts the North Fork Flathead River area of Glacier National Park, Montana, one of the least visited areas of the park and one that is recommended as wilderness.

NPS/MOLLY HANNA

(Above, right) Runner-up

Photographer Daniel Silva was impressed by the vastness of this scene, which makes the trees look small amid the colorful landscape of Theodore Roosevelt Wilderness, North Dakota.

NPS/DANIEL SILVA

(Left) Runner-up

Hikers ascend Mount Herard in Sangre de Cristo Wilderness, Great Sand Dunes National Park and Preserve, Colorado, in this image by wilderness coordinator Suzy Stutzman.

NPS/SUZY STUTZMAN

At Your Service

Wilderness Stewardship Division

By Erin Drake and Wade M. Vagias

THE WILDERNESS STEWARDSHIP Division (WSD) of the National Park Service (NPS) provides guidance, training, and technical assistance to support the protection and management of wilderness resources. More than 80% of NPS lands are managed under a wilderness prescription that takes into account wilderness character and wilderness values. The division is composed of support staff at the national office, regional offices, and wilderness park units in addition to several interagency and partner programs.

The Wilderness Stewardship Division, the national-level wilderness office housed under the Visitor and Resource Protection Directorate, provides leadership and guidance on wilderness stewardship planning, wilderness character monitoring, minimum requirement analysis, the wilderness designation process, and policy formulation. In addition, the division responds to congressional and interagency inquiries, fosters international relationships, oversees the National Outdoor Ethics (i.e., Leave No Trace) Program, collaborates with and provides training opportunities through the interagency Arthur Carhart National Wilderness Training Center, and works with science and research programs. The division is overseen by a division chief with the support of two natural resource specialists in Washington, D.C., and a training manager stationed at the Carhart Training Center in Missoula, Montana. Also at the national level, the associate director for Visitor and Resource Protection serves as the representative to the interagency Wilderness Policy Council, which consists of policy-level representatives of the four wilderness management agencies and research representatives from the U.S. Forest Service and the Department of the Interior. The council works directly with other various NPS program areas, including Fire and Aviation, Park Planning and Special Studies, and Facilities Management as well as agencies, institutions, interest groups, and the public.

At the regional and field levels, regional wilderness coordinators facilitate information exchange among the division, regions, and individual parks. Park wilderness coordinators serve as technical advisors in wilderness and backcountry management for one or more wilderness parks and are responsible for the development and implementation of the park's wilderness program. The NPS Wilderness Leadership Council, and advisory and support body composed of staff from multiple disciplines across the National Park Service, work with the Wilderness Stewardship Division chief to strengthen the agency's ability to address critical wilderness stewardship issues.

National-, regional-, and park-level wilderness staffs also coordinate with other NPS programs and councils. The division works with the NPS Inventory and Monitoring Program to collaborate on monitoring efforts that occur in wilderness.

As an interagency partner, the Wilderness Stewardship Division also provides support for the Arthur Carhart National Wilderness Training Center, a critical component in ensuring the continuity of wilderness stewardship, preservation, and education throughout the National Wilderness Preservation System. The training center strives to improve interagency and public understanding of wilderness philosophy, values, and policy through outreach and technical trainings. Read more about the training center on the following page.

To learn more about the NPS Wilderness Stewardship Division, please visit its Web site at http://wilderness.nps.gov/. National Park Service employees can also visit the program's InsideNPS page at http://inside.nps.gov/waso/waso.cfm?prg=116&lv=2.

About the authors

Erin Drake *is a master's candidate in Human Dimensions of Natural Resources at Colorado State University, Fort Collins, Colorado.* ***Wade M. Vagias****, PhD, is a management assistant at Yellowstone National Park, Wyoming. He can be reached at wade_vagias@nps.gov.*

More than 80% of NPS lands are managed under a wilderness prescription that takes into account wilderness character and wilderness values.

Lifeline for learning: The interagency Arthur Carhart National Wilderness Training Center

By Jennifer Lutman

"THE ONLY THING THAT INTERFERES with my learning is my education," said Albert Einstein. So where do managers turn to learn about wilderness? Nearly 10,000 managers and field staff have sought out the interagency Arthur Carhart National Wilderness Training Center for support. From one-day to one-week classroom courses, from online interactive training to topical wilderness stewardship toolboxes, you will find what you need to address the increasingly challenging wilderness stewardship issues you face.

Established in 1993, the Arthur Carhart National Wilderness Training Center empowers agency employees and the public to preserve their wilderness heritage through training, information, and education. The Carhart Center staff of seven includes representatives from the four wilderness management agencies: the Bureau of Land Management, U.S. Fish and Wildlife Service, USDA Forest Service, and National Park Service. Using an interagency team approach to improve consistency and coordination, the staff works with experts within and outside agency ranks to develop solutions to critical wilderness stewardship issues. The center has developed 18 classroom and online courses, including Evaluating Scientific Proposals in Wilderness, and is developing 7 more online courses to help you develop knowledge and skills in six wilderness technical core competency areas:

- Wilderness History, Law, Regulation, and Policy: Interpreting and implementing the history and laws of the National Wilderness Preservation System and agency wilderness stewardship regulations and policies.
- Managing Special Provisions: Managing the special provisions identified in the 1964 Wilderness Act and in subsequent enabling legislation.
- Wilderness Planning: Addressing wilderness stewardship needs in programmatic and project-level planning processes.
- Wilderness Field Skills: Accomplishing specific field tasks in a variety of wilderness settings.
- Visitor Use Management and Monitoring: Managing and monitoring visitor use in wilderness.
- Natural and Cultural Resources Management and Monitoring: Managing and monitoring natural and cultural resources in wilderness.

If information is what you're looking for, look no further than www.wilderness.net. Through a partnership with the University of Montana's Wilderness Institute and the Aldo Leopold Wilderness Research Institute, the Carhart Center has developed the most comprehensive clearinghouse of wilderness information and management tools available anywhere. On www.wilderness.net you will find "Toolboxes" with outlines, guidelines, examples, templates, and other resources to help you quickly and successfully address specific wilderness stewardship issues. Other sections are dedicated to wilderness law, policy, research, education, images, maps, and data.

If you want expert advice from managers who have addressed the issues you are facing, check out connect.wilderness.net. Wilderness Connect is the only social networking site for the professional wilderness community and a place where you can have real-time discussions with government employees, academia, and educators concerning science, research, management, and other wilderness issues.

Arthur Carhart: 1892–1978

In 1919 Arthur Carhart, the first landscape architect in the U.S. Forest Service, was sent to Trappers Lake, Colorado, to plot the shoreline for road access and several hundred vacation homes. He returned to his office and instead wrote, "There is a limit to the number of lands of shoreline on the lakes; there is a limit to the number of lakes in existence; there is a limit to the mountainous areas of the world, and … there are portions of natural scenic beauty which are God-made, and which of a right should be the property of all people." Today, Trappers Lake, in the Flattops Wilderness, remains without roads or homes.

As the 50th anniversary of the Wilderness Act approaches, one question arises: What will the next 50 years look like for wilderness? The fate of the National Wilderness Preservation System depends largely on the value younger generations put on our wild places, so future Carhart Center efforts include expanding outdoor education efforts and exploring new opportunities in the world of social media and online training.

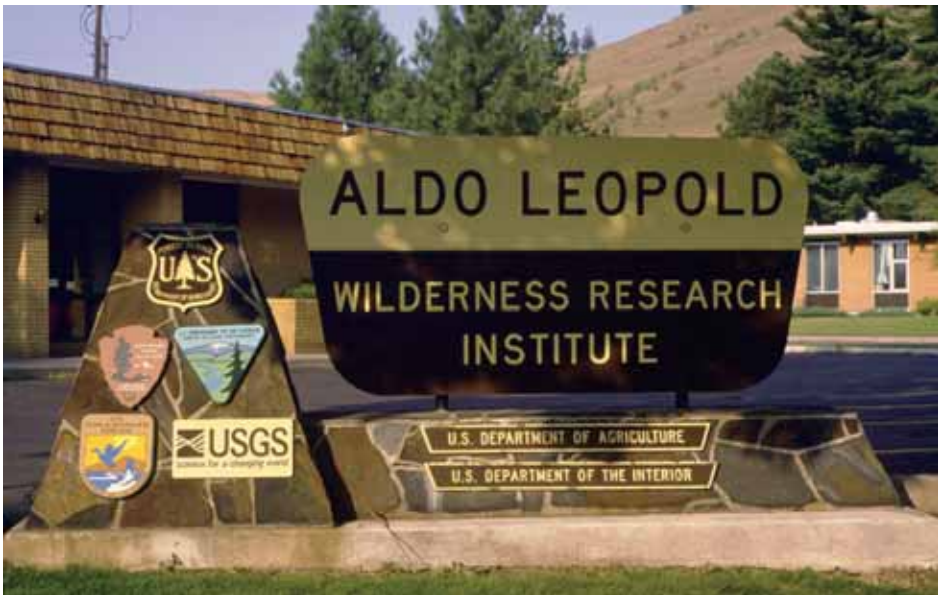
As long as there are wild places to protect, the Carhart Center will continue to support the field through training, information, and education efforts. Learn more about the Carhart Center at http://carhart.wilderness.net.

About the author

Jennifer Lutman *was the Student Conservation Association education and outreach intern, 2009–2011, with the Arthur Carhart National Wilderness Training Center, James E. Todd Building, 32 Campus Drive #3168, Missoula, Montana 59812-3168. You can contact the center at (406) 243-4682.*

What would Aldo do? The Aldo Leopold Wilderness Research Institute

By staff of the Aldo Leopold Wilderness Research Institute



LEOPOLD INSTITUTE

THE SCIENCE AND APPLICATION STAFF at the Aldo Leopold Wilderness Research Institute often pause to look back to seek guidance from the teachings of our namesake. Aldo Leopold lived in a very different time and situation than we do now, but he recognized the looming threats to our nation's ethical relationship with wild places. We are thankful for his foresight and commitment, as well as for his contribution to motivating others to protect these places we call wilderness. We also acknowledge the influence of his teachings on our science program today.

The creation of the Leopold Institute in 1993 placed U.S. Forest Service wilderness scientists at an interagency institute designed to be more responsive to the National Park Service (NPS), the Bureau of Land Management, and the U.S. Fish and Wildlife Service by making the science needed to support management decision making more accessible. The Leopold Institute is managed by the U.S. Forest Service Rocky Mountain Research Station, but since its beginning has added U.S. Geological Survey scientists, hired a director formerly with the National Park Service, and expanded scientific and application staff in response to growing scientific issues across the National Wilderness Preservation System. As of 2011 the institute has a fire ecologist, a social scientist, a zoologist, a recreation ecologist, a landscape ecologist, and a vibrant technical and application staff focused on GIS applications, monitoring support, and getting information out to managers. We have grown just as the challenges to wilderness have grown.

To capture the growing recognition of the scientific values of wilderness and to understand the flow of off-site benefits to varied stakeholders require continued growth in intellectual capacity at the Leopold Institute. The institute continues to be at the heart of everything wilderness in the United States and around the world, anxious to understand changing threats to wilderness and new opportunities to bring benefits to the current and future public. The Leopold Institute has been at the center of development and publication of the International Journal of Wilderness, the World Wilderness Congress, and wilderness science conferences and workshops in the United States. Science and application staff make many presentations on scientific findings and application every year. To view current information on the Leopold Institute work program, to access publications, or to identify the correct person to contact for information, please visit the Leopold Institute Web site at www.leopold.wilderness.net.

PS

The institute continues to be at the heart of everything wilderness in the United States and around the world.

The Wilderness Leadership Council

The National Park Service (NPS) Wilderness Leadership Council (WLC), formed in 1996 as the National Wilderness Steering Committee, serves as an advisory body to the NPS Director on all Service-wide wilderness matters and aids the NPS in enhancing the agency's ability to address critical wilderness stewardship issues. Composed of superintendents and staff from multiple levels and program areas across the NPS, the WLC also:

- Facilitates the understanding of wilderness stewardship as a core mission, as virtually all disciplines have important roles and responsibilities in wilderness
- Encourages the NPS to become a leading partner in wilderness stewardship efforts within the National Wilderness Preservation System
- Coordinates with the NPS Wilderness Stewardship Division and aids in interagency wilderness planning and initiatives

The WLC has succeeded in promoting communication strategies in support of wilderness designation, providing guidance on NPS policy, Director's Orders, and Reference Manuals, and advancing interagency program reviews. The council believes wilderness stewardship is critical to the future of our wilderness lands and will continue to support wilderness training initiatives, advocate science-based wilderness management decisions, and maintain a strong dedication to communicating with parks and regions on wilderness issues. To learn more or to get involved with the WLC, please e-mail Sean McGuinness at sean_mcguinness@nps.gov.

—***Ryan Michelle Scavo***
Program Assistant, Wilderness Stewardship Division, NPS Washington Office

The National Wilderness Stewardship Alliance

The National Wilderness Stewardship Alliance (NWSA) was formed in 2010 as a nonprofit, 501(c)(3) organization with the mission of developing a network of volunteer-based organizations working together to provide stewardship for America's enduring resource of wilderness. The NWSA works in cooperation with the four National Wilderness Preservation System agencies to connect volunteer-based wilderness stewardship organizations with one another, direct groups to resources, and foster new wilderness stewardship organizations. A Memorandum of Understanding signed in 2011 governs cooperation between the NWSA and the National Park Service.

The NWSA can assist wilderness managers in three primary areas:

- Site-specific volunteerism. Member organizations can educate visitors, staff visitor centers, organize and host community activities, and generally promote volunteer opportunities.
- Monitoring of wilderness character conditions. Members can engage in wilderness character monitoring, including field reconnaissance and data entry.
- Site-specific management issues. Members can engage in a variety of field projects, such as trail rehabilitation, treatment of invasive species, and posting trail signage.

How can the NWSA help you meet your wilderness stewardship responsibilities? Visit our Web site at http://wildernessalliance.org or e-mail the author, Dave Cantrell, chair of the board, NWSA, at cantrell@verinet.com.

—***Dave Cantrell***
Chair, National Wilderness Stewardship Alliance, P.O. Box 5293, Reno, Nevada 89513

COURTESY OF JON JARVIS

Director Jarvis enjoys a hike in Yosemite National Park, California.

A conversation with NPS Director Jonathan B. Jarvis

By Wade M. Vagias, guest editor

With a career spanning more than three decades, much of it dealing with wilderness, National Park Service (NPS) Director Jon Jarvis is in a special position to offer his perspective on wilderness stewardship and science. On 1 April 2011 I discussed with Jon the challenges and issues faced by NPS wilderness managers and the interface of science with stewardship of wilderness resources.

Relevance of wilderness

Wade Vagias (WV): Enhancing park relevancy is a goal you cite frequently. Why should wilderness matter to society, NPS employees, and the National Park Service?

Jon Jarvis (JJ): Wilderness, to the majority of the American public, is more of an idea than a real thing. Most Americans are not going to experience wilderness in the way our [NPS] rank and file do. Nevertheless, I know that if the American public did not care about wilderness and wild places, we would have never set aside half of Alaska, including the Arctic National Wildlife Refuge, and places like the Grand Canyon and Yellowstone. Abraham Lincoln would not have set aside Yosemite during the Civil War if we as a society didn't place deep core values on wild places. Wilderness evokes a passion among people; they take comfort in knowing there are places intentionally left wild: "Someday I might actually get to see that, or maybe not, but I just like to know it exists. Even though I will probably never see a panther or a wolf or a grizzly bear, it's cool to know that they exist and that their habitat is protected." Wilderness, in some ways, represents this broader American ethos—that we as a society have decided to retain a piece of that wildness, even if it has meant imposing constraints on our desire to dominate everything. For employees of the National Park Service, wilderness is the touchstone, the standard, by which we measure our success in preserving these places and their ecological systems for future generations.

Climate change

WV: One of the most significant issues facing protected area managers is climate change. We are witnessing mass tree mortalities, upslope migration of species, and perennial streams becoming seasonal, among many other changes. What role(s) do you envision wilderness playing in regard to climate change?

JJ: As I've said publicly and before Congress, climate change is the biggest threat we have ever faced in terms of integrity of the National Park System.

In many ways, wilderness is at the center of the issue because what we have assumed to be natural systems, and the actions we take to protect them such as controlling exotics and restoring native species, are being turned on their head. We are finding mercury in high-elevation lakes; nitrogen is coming over from coal-fired power plants of China. I was in the Virgin Islands a couple weeks ago and the park staff said, "Oh, the Sahara dust is up today." Imagine, dust from the Sahara Desert travels across the Atlantic and impacts the Virgin Islands! We are beginning to realize how interconnected the world's systems are and that they are affecting wilderness—often in pronounced ways. That means a couple things. To a certain degree, we're going to have to be more active in managing these systems. We've been active in terms of restoration and passive in everything else. We're going to have to begin to manage wilderness for standards of resilience because some species are going to be pushed over the edge.

We have managed parks and wilderness as islands, and if there is a silver lining to climate change, it is that it is forcing us to think at the landscape scale. Connectivity, redundancy, and resilience are coming into play, and in a way that goes beyond just the National Park Service to include our partners with Fish and Wildlife, Forest Service, Bureau of Land Management, state agencies, and that's a good thing. But to address the challenges created by climate change will force us to rethink some of our foundational beliefs, the actual premises upon which we have managed for a long time.

Abraham Lincoln would not have set aside Yosemite during the Civil War if we as a society didn't place deep core values on wild places. Wilderness evokes a passion among people; they take comfort in knowing there are places intentionally left wild.

Restoration

WV: Is active manipulation—restoration—ever justifiable in designated wilderness, and if so, is there an example you would cite?

JJ: I don't necessarily subscribe to the notion that wilderness management is hands-off. I have been managing wilderness for most of my career and it's practically a myth that you cannot *not* manage wilderness. Today within designated wilderness, we are managing the public, exotic species, fire, cultural resources, and science, all of which are included in the Wilderness Act. Now we are adding a new element: restoration. I keep going back to the term "resilience" and our need to look at wilderness in the landscape-scale context and the recognition that we may be managing a species that might be forced to migrate. Wilderness will lose its value if it's fake and various pieces have moved on or become extinct. What if something new moves in, driven by climate change? How do we treat that? If javelinas show up in Washington State because of climate change, are they exotics? We need to be aware that anthropogenic changes are occurring in wilderness that we must face head on.

Valuation of natural resources

WV: Affixing a dollar figure to ecosystems and the services they provide can be contentious, yet events like the breaching of Grand Ditch in Rocky Mountain National Park and the *Deepwater Horizon* oil spill necessitate our ability to do so. How should we best frame the question "what is a wilderness worth?"

JJ: We should not be so naive to think that we can justify wilderness on either straight moral values or straight economics. We must use both. We've been relatively articulate on the moral value side and relatively inarticulate on the economic value side. Wilderness protection only exists by the will of the people. Thus we must advance our ability to quantify and describe the values of wilderness. There are other areas, too, that need to be explored. One is the evidence that the economy of a community in close proximity to wilderness is more resilient to economic downturns than the economy of a similar community not in close proximity to a wilderness. One of my favorite quotes by Luther Propst of the Sonoran Institute is "Whoever makes the economic argument first, wins." We always have to be prepared to make an economic value argument.

Cultural resources

WV: Management of cultural resources in wilderness is at times contentious, yet humans have been using and manipulating the landscape for millennia, including areas that are now designated wilderness. What challenges come to your mind with managing cultural resources in wilderness? How can the National Park Service be better stewards of both wilderness and cultural resources in wilderness?

JJ: In the National Park Service, I don't think we necessarily see as much of a conflict between cultural resources and wilderness as certain constitu-

NPS/DAN KIMBALL

Director Jarvis (right) joins Superintendent Dan Kimball on a "slough slog" in Everglades National Park, Florida.

ency groups who don't believe cultural resources should remain or be of value in wilderness. Internally, there is an understanding that they [wilderness and cultural resources] both are valued.

Technology

WV: Technology is fundamentally changing society. What concerns do you have about emerging technologies' influence on wilderness? Are there new or emerging technologies that will enhance our ability to be effective wilderness stewards?

JJ: At the [2011] George Wright conference somebody asked a question about the use of technology in the outdoors and I just said, "Get over it." I think it's an incredible waste of time to argue about technology in the outdoors. Are we still hiking in wool with hand-woven wicker packs? No. Look at the technology in a modern backpack: carbon fiber, Gore-Tex, ripstop nylon. But then we say, "Don't take your BlackBerry." I don't understand why we've singled out that particular aspect of technology and labeled it "bad." I believe a lot of it is driven by age, which is interesting because as we backpackers get older we like our comfort technology—the super-high-density foam bed so our bones don't poke through into the ground. But we rail against the handheld technological devices like GPS and a data link that could be of extraordinary value in a rescue, or even for knowledge about a particular place where you are.

During the America's Great Outdoors listening sessions we held around the country, the adult sentiment was "They [young people] need to take the wilderness like I got it. Leave that technology at home." And when we did the listening sessions with young people [24 or under], we heard: "I'm bringing it with me. What I want is high-speed Internet and high-speed wireless access in the backcountry so that I can share this experience with my Facebook friends." Those young people are going to be running the show soon. It's not like we're going to have a choice. What we need to be focusing on is developing the kind of applications that are useful, that deepen the wilderness experience, not detract from it. With young people today, it's about accessing information. It's all about "At any given moment, I can access information to get the answer I need." If I'm out in the woods and see a mushroom that I am interested in eating, I would love to be able to take a picture of it and within 30 seconds know whether I can eat it or not [laughter]. Like I said, technology is here to stay; "get over it."

International coordination

WV: Landscape-scale protection of resources often requires coordination across political borders. Last November at WILD 9—the international wilderness and biodiversity conference—in Mérida, Mexico, you signed a trilateral memorandum of understanding (MOU) with Canada and Mexico for wilderness conservation. What opportunities do you envision regarding international efforts to promote landscape-scale protection? And is there anything specific regarding the WILD 9 MOU we should look for?

JJ: Perhaps the most concrete example we are working on is reopening the Rio Grande crossing from Big Bend National Park to Boquillas del Carmen in Mexico. Secretary Salazar is in Mexico this week meeting with the Mexican Secretary of Environment with the goal of enhancing the relationship between the national parks on both sides of the border and reopening the crossing at Boquillas. It will not be like it was in the old days when you climbed down the bank, got in a boat, went over, and got your burrito and Tecate. Now you're going to show your passport,

go through security, climb down the bank, get in the boat, go over, and get your burrito and Tecate [laughter]. It will be a little different, but the symbolism of being able to re-open that connection between Mexico and the United States is huge. It not only reaffirms our relationship with Mexico but also sets a new framework for this relationship.

I believe these cross-border relationships around wilderness or other protected areas are a game changer for us. We have a long history of collaboration with Canada, particularly at Waterton-Glacier [International Peace Park]. And while we do have a very contentious border with Mexico, the trilateral MOU gives us a new and positive framework for moving forward. I believe, as we've been working with Landscape Conservation Cooperatives, that a boundary is nothing more than a line on a map.

Role of science

WV: As noted in the 1964 Wilderness Act, wilderness has multiple values, including scientific inquiry. What suggestions do you have for managers who are trying to balance science in wilderness?

JJ: When I was superintendent of Wrangell–St. Elias National Park and Preserve (Alaska), a group of scientists wanted to run a series of dynamite charges across the Bagley Icefield. Doing so would give them a fairly accurate measurement of the thickness of the ice. They produced a legitimate proposal but I denied it. They could not believe that I denied it and I said, "That's designated wilderness and you're going to go out there and set off dynamite on the surface of the glacier?" And they said, "Well, there's no one out there." I said, "Well you don't really know that. And if there is, their expectation of wilderness experience is absolutely the highest priority. There could be somebody out there cross-country skiing across the icefield and then you go out there and set off dynamite—you have totally ruined that person's experience." The information to be derived from that research versus its impact wasn't justified in my mind. This was before climate change was really gnawing at us.

Proposals for scientific activity in wilderness must be done in such a manner that it maintains and does not impair wilderness character and must be run through a minimum requirement analysis.

There are ways that science can take place in wilderness, and we have to educate the scientists on what wilderness is and appropriate ways to conduct science in wilderness. Proposals for scientific activity in wilderness must be done in such a manner that it maintains and does not impair wilderness character and must be run through a minimum requirement analysis. In fact, wilderness policy encourages us to work with emerging technologies to develop the least intrusive forms of instrumentation and research to both advance our understanding of natural systems and to minimize impacts. Most parks that manage wilderness have the policies in place, and we've used them over and over to identify the impacts to wilderness character and to the visitors' expectations.

Future of wilderness

WV: In three years we will celebrate the 50th anniversary of the Wilderness Act. What do you see as the most significant challenges for wilderness stewardship in the next 50 years, and what advice would you give to wilderness managers to help them meet those challenges?

JJ: The biggest challenge is getting a whole new constituency to experience wilderness. It's one thing to appreciate the concept of wilderness, but it's a whole different thing to sleep in the high country of the Sierras under the stars, or take a paddle trip in the Everglades. We've seen it with young people over and over: wilderness can be life-changing in some sort of chemical, magical way. We don't have enough programs to get kids out into that experience. We as an institution must be willing to put energy into making it happen. We have a culture of "build it and those who want to come will come," and we need to change that mind-set. Connecting a new generation is critical to another 50 years of the Wilderness Act and 100 years of NPS stewardship. We have to bring them to the resource and then bring them back again. Regardless of ethnicity or socioeconomic background, wilderness can have the same effect, the same impact on lives. It is up to us to provide opportunities to youth to experience wilderness. It will take an aggressive effort, but the stakes are too high. The 50th anniversary is a great event to celebrate our successes, but we cannot rest on those achievements alone and assume that what we did for the last 50 years is going to work for the next 50.

Invited Features

Fires in wilderness in the national parks*

By Jan W. van Wagtendonk

Abstract

Historically, the only fire policy practiced by federal land management agencies was suppression, a policy that remained in place until the National Park Service officially recognized fire as a natural process in the late 1960s. The policy change allowed lightning fires ignited in specially designated management zones of some parks to run their course under prescribed conditions. The programs grew slowly as managers became comfortable with allowing fires to burn under controlled conditions, predominantly in wilderness areas. Events such as the Yellowstone fires in 1988 and the Cerro Grande Fire in 2000 resulted in reviews and updates of federal fire management policies that changed the Service's policies. Today, wilderness fire management is a vital component of the fire and fuels programs of many units of the National Park Service. Because of increasing budget and smoke management constraints, the future of restoring and maintaining fire-prone ecosystems will need to rely increasingly on the use of fire in wilderness.

Key words

fire management, natural fire, prescribed fire, wilderness, wildland fire

FIRE HAS BEEN A DYNAMIC ECOLOGICAL FORCE IN FIRE-prone ecosystems for millennia. As a natural process, fire is an integral part of the structure and function of park and wilderness ecosystems. The 1916 National Park Service Organic Act states that parks will be left unimpaired for the enjoyment of future generations, and the 1964 Wilderness Act states that wilderness will be protected and managed so as to preserve its natural conditions. Implicit in these statements is that fire should play out its natural role: humans should minimize their intervention in ecological processes so that landscapes continue to be shaped by natural forces.

Not until humans felt the need to control or use fire was its role altered in natural ecosystems. Native Americans were the first humans in North America to influence fire regimes by setting fires to drive game and thwart enemies, by using fire to enhance the production of food items and basketry materials, and by controlling fires near their villages. When Europeans arrived in North America, they caused more extensive changes to fire regimes by converting forests and grasslands to farms, by indiscriminate burning, and by trying to extinguish human-caused and lightning-caused fires near settlements whenever possible. Some European settlers also used forms of prescribed fire to clear lands and open up understory vegetation for a variety of purposes. Systematic federal wildland fire management did not occur until the late 1800s, when federal land was set aside as parks and forest reserves. The 1910 fires in northern Idaho represented a turning point in the transition to coordinated federal suppression response and attendant policies and budgets.

Fire protection years, 1886–1967

Yellowstone National Park (Wyoming, Montana, and Idaho) was established in 1872 as the world's first national park. For the next several years, administration of the park languished until the U.S. Army was assigned the responsibility for its protection in 1886. Upon its arrival in the park, the Army found numerous fires burning in developed areas as well as in areas where it was not reasonable to control them. The Army did not have enough personnel to fight all the fires, and thus came the first decision by a manager of federal land to allow some fires to burn and to control others. The decision was pragmatic, based on availability of firefighting resources rather than recognition of beneficial effects.

This policy of fire suppression was similarly applied to Sequoia, General Grant, and Yosemite National Parks (California) when they were established in 1890, and regular patrols were initiated to guard against fires. The National Park Service was established in 1916 and took over management from the Army, yet fire suppression remained the official policy in the national parks for the next five decades.

In 1962 the Secretary of the Interior asked a committee to look into wildlife management problems in the national parks. This committee, named after its chair, Dr. Starker Leopold, son of Aldo Leopold, did not confine its report to wildlife, but took the broader view that parks should be managed as holistic systems (Leopold et al. 1963). The committee recognized fire as a critical process in many natural ecosystems and pointed out the negative effects in some ecosystems as a result of a fire policy totally dominated by fire suppression. During the same period, the 1964 Wilderness Act was passed, which firmly established the protection and preservation of natural conditions in wilderness areas.

Experimental years, 1968–1977

As a result of the Leopold report and the Wilderness Act, the National Park Service changed its policy in 1968 to recognize fire as an

*This article was adapted from one previously published: van Wagtendonk, J. W. 2008. The history and evolution of wildland fire use. Fire Ecology 3(2):3–17.

Table 1. Evolution of National Park Service fire policy

Era	Years	Policy Direction	Watershed Event
Fire protection	1886–1967	Suppress fires when and where resources are available; becomes official policy following establishment of the National Park Service in 1916.	1910: Fires in Idaho and Montana, including Glacier National Park, solidify suppression as sole policy.
Experimentation	1968–1977	Fire recognized as a necessary ecological process; parks experiment with naturally ignited fires.	1963: Leopold report on wildlife management in national parks prompts National Park Service in 1968 to recognize fire as a natural ecological process.
Reevaluation	1978–1989	Prescribed natural fire program suspended in the Rocky Mountains; fire policy review team evaluates NPS and U.S. Forest Service wilderness fire policies, recommending clear decision criteria, accountability, and cooperation.	1978: Ouzel Fire threatens community adjacent to Rocky Mountain National Park. 1988: Yellowstone fires lead to review of agency fire management policies.
Maturation	1989–1999	Task group writes policy implementation guide, reinvigorating languishing wildland fire use programs and giving managers support to enable growth and development of these programs.	1994: South Canyon Fire results in 14 firefighter deaths in Colorado, prompting comprehensive review of federal wildland fire policy a year later. Fire management plans are revised under the guidelines and programs begin to be implemented.
Cerro Grande (present era)	2000–2010	Secretaries of Agriculture and the Interior reconvene policy review group, which mandates approved fire management and operational plans. Wildland Fire Coordinating Group allows broader range of management responses. In 2009, policy defines and distinguishes between "wildfire" and "prescribed fire."	2000: Cerro Grande Fire causes massive destruction in Los Alamos, New Mexico. Other fires that year in Montana precipitate 2001 review of the 1995 federal wildland fire policy. National Park Service continues to allow wildland fires to burn for multiple objectives, but air pollution, threatened and endangered species, and proximity to urban areas are significant issues in decision-making process.

ecological and necessary process. Sequoia and Kings Canyon National Parks, California, established a natural fire management zone in 1968 immediately after the policy changed (Kilgore and Briggs 1972; Parsons et al. 1986) and began the first tentative experiments with managing naturally ignited fires deep in the park wilderness.

Saguaro National Monument (now Saguaro National Park, Arizona) was the next park to initiate a wilderness fire program, in 1971. The program required that all natural fires be extinguished except those that occurred during the monsoon season between 1 July and 15 September and that met a set of prescribed conditions (Gunzel 1974). Yosemite National Park started its "Natural Fire Management" program in 1972 (van Wagtendonk 1978). The first test of the program came in 1974 when the Starr King Fire burned over 1,500 ha (3,700 ac) and had to be controlled on one side to prevent smoke from drifting into Yosemite Valley. At the same time as the Starr King Fire was burning in Yosemite, Grand Teton National Park (Wyoming) was contending with the equally large Waterfall Canyon Fire. Considerable public outcry occurred when smoke obscured the mountains, and some accused the park of having a "scorched earth" policy (Kilgore 1975). Although these early programs did not occur in congressionally designated wilderness, the term "wilderness fire" was used informally by the Service for naturally ignited fires in large remote areas of the parks.

Reevaluation years, 1978–1989

Two events in 1978 and 1988 precipitated major fire reviews. The Ouzel Fire was ignited in Rocky Mountain National Park (Colorado) by lightning on 19 August 1978 and allowed to burn as part of the park's "prescribed natural fire" program. The fire was monitored for more than a month before high winds caused it to threaten a community outside the park's boundary. After the fire was controlled, a board of review concluded that the fire plan was not properly implemented, did not adequately incorporate ecological information about the park, and did not put enough emphasis on external considerations such as adjoining development (Laven 1979). The Rocky Mountain National Park–prescribed natural fire program was suspended pending revision of the plan.

Ten years later, the fires of 1988 burned 562,310 ha (1,389,500 ac) in the greater Yellowstone area. Based on a wildland fire plan written in 1972, Yellowstone National Park allowed several lightning-ignited fires to burn in a remote corner of the park in late June. At the same time, U.S. Forest Service fire managers were monitoring another lightning ignition just north of the park. By the end of July, unusually dry conditions coupled with high winds persuaded managers of both agencies to suppress all fires that were currently burning, as well as all new starts (Schullery 1989). Ultimately, nine major fires accounted for 95% of the area burned in 1988 in the greater Yellowstone area. Six of those fires were ignited outside the park, and four of them were human-caused. The Secretaries of Agriculture and the Interior convened a fire policy review team to evaluate the National Park Service and U.S. Forest Service wilderness fire policies. The team reaffirmed the fundamental importance of fire's natural role but recommended that fire management plans be strengthened by establishing clear decision criteria and accountability, and that interagency cooperation be improved (Rothman 2007).

Maturation years, 1989–1999

All federal fire programs were affected by the Bureau of Land Management's 1994 South Canyon Fire in Colorado. Suppression action was taken on the lightning-ignited wildfire within two days of ignition, but a blowup two days later killed 14 firefighters. An interagency investigation team was formed and issued their report in August 1994. They cited several direct and contributory causes of the fatalities, including fire behavior and incident management procedures (Rosenkrance et al. 1994).

The incident led to the first comprehensive review and update of federal wildland fire policy in decades. The report reiterated that the first priority of all federal wildland fire programs was firefighter and public safety (Philpot et al. 1995). With regard to prescribed fires and prescribed natural fires, including those in wilderness, the report stated, "Wildland fire will be used to protect, maintain, and enhance resources and, as nearly as possible, be allowed to function in its natural ecological role." In 1998 the agencies convened a task group to write a policy implementation guide for moving the policies into action. This guide used the term "wildland fire use" to refer to wildland fires used to achieve resource benefits, previously labeled "prescribed natural fires." By the end of the decade, the 1995 policy and 1998 implementation guide reinvigorated languishing "wildland fire use" programs and gave managers the support they needed to enable the programs to continue to grow and mature.

Cerro Grande and beyond, 2000–2010

A prescribed fire set by fire managers on the Bandelier National Monument (New Mexico) in 2000 was declared a wildfire, and a backfire that the incident management team ignited escaped onto the adjacent national forest. The fire extended into the Los Alamos National Laboratory and the town of Los Alamos. Over 19,400 ha (48,000 ac) were burned and 255 homes destroyed before it was extinguished. As a result, the Secretaries of Agriculture and Interior reconvened the interagency federal wildland fire policy review working group to review the status of the implementation of the 1995 policy. The group found that the policy was generally sound and continued to provide a solid foundation for wildland fire management activities (Douglas et al. 2001) in and out of wilderness. The guidance for the use of wildland fire remained the same as in 1995, except the following sentence was added: "Use of fire will be based on approved fire management plans and will follow specific prescriptions contained in operational plans." The working group found that the multiple terms used to describe wildland fires were confusing, but were silent on the terminology they preferred.

As a result of the 2001 policy recommendations, an interagency team revised the 1998 wildland fire use implementation guide based on the 1995 policy (USDA and USDI 2005). The new document provided direction, guidance, and assistance for planning and implementation of wildland fire use for all federal wildland fire agencies. In order to be consistent with terminology, the National Wildland Fire Coordinating Group (2006) officially endorsed the term "wildland fire use." The new range of appropriate management responses to a wildland fire varied from monitoring to aggressive suppression action near communities.

In 2009 the departments issued updated guidance for implementation of the federal wildland fire management policy (USDA and USDI 2009). The guidance states that wildland fires are categorized into two distinct types, wildfires and prescribed fires. Wildfires are unplanned ignitions, such as fires caused by lightning, volcanoes, or unauthorized and accidental human-caused fires. Prescribed fires are wildland fires originating from a planned ignition to meet specific objectives identified in a written and approved prescribed fire management plan. A wildfire may be concurrently managed for one or more objectives, and objectives can change as the fire spreads across the landscape. The response to wildfire will be "based on ecological, social, and legal consequences, the circumstances under which a fire occurs, and the likely consequences on firefighter and public safety and welfare, natural and cultural resources, and values to be protected" (USDA and USDI 2009). Wilderness fires, which at various points of the evolution of federal fire policy were also called prescribed natural fires or wildland fire use fires, no longer exist as a unique category, but can occur if the park's approved fire management plan allows for management of wildfires to achieve resource objectives. However, wilderness continues to be the primary area where wildfires are allowed to burn. Not only is wilderness often remote, but proper management of these areas requires protection of solitude, natural ecological processes, and minimization of management actions such as wildfire suppression.

Future years

Although the National Park Service led the effort to allow lightning-ignited fires to burn under prescribed conditions, the agency has become increasingly restrictive in its approach to wildfire use in and out of wilderness areas. Smoke, threatened and endangered species, the risk posed by long-term events to nonfederal lands, and the uncertainty of potential impact should fires grow beyond expected boundaries have been major concerns. The small size of many parks and wilderness areas, and their proximity to urban areas, exacerbate these problems.

Air quality poses one of the biggest challenges for managers of wildland fire use programs.

Air quality poses one of the biggest challenges for managers of wildland fire use programs. Fires may cast palls of smoke in inhabited areas and can cause air quality standards to be exceeded. Active measures, such as timing ignitions during periods of good smoke dispersion, can mitigate some of these conditions, and steps can be taken to inform local air pollution control boards about the importance of wildland fire programs for meeting land management objectives.

Even with these constraints, the National Park Service remains the leader among federal agencies in allowing wildland fires to burn under prescribed conditions in wilderness. These fires assist in maintaining parks in an unimpaired state, which is central to the NPS Organic Act and Wilderness Act. The ecological rationale for wilderness fire supports the continuation of the program in the future, and wilderness character objectives that discourage intervention in natural processes such as fire also support the program's existence. However, climate change, the continuing encroachment on wildlands adjacent to parks and wilderness by human development, and the conflicting societal perceptions of park purposes will need to be taken into consideration. For example, many park visitors are upset when their scenic views are obscured by smoke. Large wildernesses and parks will continue to be important for understanding the long-term role fire plays in ecosystems and how to allow fire to function as a dynamic ecological process.

Literature cited

Douglas, J., T. J. Mills, D. Artly, D. Ashe, A. Bartuska, R. L. Black, S. Coloff, J. Cruz, M. Edrington, J. Edwardson, R. T. Gale, S. W. Goodman, L. Hamilton, R. Landis, B. Powell, S. Robinson, R. J. Schuster, P. K. Stahlschmidt, J. Stires, and J. van Wagtendonk. 2001. Review and update of the 1995 federal wildland fire management policy. U.S. Department of the Interior and U.S. Department of Agriculture, Washington, D.C., USA.

Gunzel, L. L. 1974. National policy change: Natural prescribed fire. Fire Management 35(3):4–8.

Kilgore, B. M. 1975. Restoring fire to national park wilderness. American Forests 81(3):16–19, 57–59.

Kilgore, B. M., and G. S. Briggs. 1972. Restoring fire to high elevation forests in California. Journal of Forestry 70:266–271.

Laven, R. D. 1979. Natural fire management in Rocky Mountain National Park: A case study of the Ouzel Fire. Pages 37–41 *in* R. M. Linn, editor. Proceedings of the Second Conference on Science in the National Parks. National Park Service Transactions and Proceedings Series 6. National Park Service, Washington, D.C., USA.

Leopold, A. S., S. A. Cain, C. M. Cottam, I. N. Gabrielson, and T. L. Kimbal. 1963. Wildlife management in the national parks. Pages 1–8 *in* Transactions 28th North American Wildlife and Natural Resources Conference. Wildlife Management Institute, Washington, D.C., USA.

National Wildfire Coordinating Group. 2006. Glossary of wildland fire terminology. PMS-205. National Wildfire Coordinating Group, Incident Operations Standards Working Team, Boise, Idaho, USA.

Parsons, D. J., D. M. Graber, J. K. Agee, and J. W. van Wagtendonk. 1986. Natural fire management in national parks. Environmental Management 10(1):21–24. doi: 10.1007/BF01866414.

Philpot, C., C. Schechter, A. Bartuska, K. Beartusk, D. Bosworth, S. Coloff, J. Douglas, M. Edrington, R. Gale, M. J. Lavin, L. K. Rosenkrance, R. Streeter, and J. van Wagtendonk. 1995. Federal wildland fire management policy and program review. U.S. Department of the Interior and U.S. Department of Agriculture, Washington, D.C., USA.

Rosenkrance, L. K., M. A. Reimers, R. A. Johnson, J. B. Webb, J. H. Graber, M. Clarkson, P. Werth, S. J. Husari, D. Mangan, and T. Putman. 1994. Report of the South Canyon Fire accident investigation team. Bureau of Land Management and U.S. Forest Service, Washington, D.C., USA.

Rothman, H. K. 2007. Blazing heritage: A history of wildland fire in the national parks. Oxford University Press, New York, New York, USA.

Schullery, P. 1989. The fires and fire policy. Bioscience 39(10):686–694.

U.S. Department of Agriculture and U.S. Department of the Interior. 2005. Wildland fire use implementation procedures reference guide. U.S. Department of Agriculture and U.S. Department of the Interior, Washington, D.C., USA.

———. 2009. Guidance for implementation of the federal wildland fire policy. U.S. Department of Agriculture and U.S. Department of the Interior, Washington, D.C., USA.

van Wagtendonk, J. W. 1978. Wilderness fire management in Yosemite National Park. Pages 324–335 *in* E. A. Schofield, editor. EARTHCARE: Global protection of natural areas. Westview Press, Boulder, Colorado, USA.

———. 2008. The history and evolution of wildland fire use. Fire Ecology 3(2):3–17. doi: 10.4996/fireecology.002003.

About the author

Jan W. van Wagtendonk *is a Research Forester Emeritus with the U.S. Geological Survey, Western Ecological Research Center, Yosemite Field Station, El Portal, California, 95318, USA. He can be reached at (209) 379-1306 and by e-mail at jan_van_wagtendonk@usgs.gov.*

Transboundary cooperation to achieve wilderness protection and large landscape conservation

Figure 1. Compatible management of the Flathead River, pictured here in British Columbia, Canada, is critical to the long-term survival of Glacier National Park's native trout, many of which spawn upstream in Canada.

By Harvey Locke

THE IDEA THAT NATIONAL PARK MANAGERS SHOULD BE thinking across borders is not new, but the worldwide recognition of the need to do so at the landscape scale is. A combination of findings from the conservation science disciplines has identified coordinated planning and management actions across political borders as essential components of a landscape-scale approach to conservation. At the dawn of the 21st century, we have awakened to a new view in which large, natural resource–based national parks have become the indispensable centerpiece of a landscape-scale approach to conservation.

For park managers this recognition necessitates considering how a park's actions fit into a broader context, including the allocation of limited resources both within and outside park borders. An understanding of how large landscape conservation came to be the new imperative and what it means for the future of wild nature will help park managers to make better-informed decisions that lead to a more sustainable future for the national parks and the species and processes they protect.

The development of an idea

Every national park manager knows that Yellowstone, created by the Congress in 1872, was the world's first national park and that the idea quickly spread around the world, first to Australia, Canada, and South Africa and later to Europe, South America, Asia, and other parts of Africa (Locke 2009). By 1900 these areas were essential to the preservation of large mammals and played a critical role in preventing their extinction around the world (Roosevelt 1994).

Sixty years after the creation of Yellowstone, the next great park innovation with a global impact was the Peace Park concept, which recognized that two parks in the Rocky Mountains, Waterton Lakes National Park of Alberta, Canada, and Glacier National Park in Montana, were part of the same landscape and should be managed cooperatively (fig. 1) (Konstant et al. 2005; Locke and McKinney *in press*). Culturally, there was also great symbolism in the name "peace park" and in the fact that in 1932 both Congress and the Canadian Parliament acted legislatively to create the world's first. The concept of peace parks has similarly spread around the globe, becoming an important part of both conservation and border conflict resolution, particularly among the countries in southern Africa (Ali 2007). Even without a formal peace park designation, the park-centered approach to shared stewardship across borders may serve to resolve tension and improve relationships, as is unfolding today along the U.S.-Mexico border. Recently the U.S. Department of the Interior National Park Service (NPS) has been working with Mexican counterparts to establish an "area of binational environmental interest" that includes reopening the Rio Grande crossing from Big Bend Na-

Abstract
Large intact wilderness areas remain the cornerstone of any conservation effort; however, they alone are insufficient to secure the perpetuation of the species and processes they are meant to protect. Scientific studies of species extinction patterns, natural processes, and climate change adaptation have established the need to move from managing at the park level to working across entire landscapes. This evolution in thinking is being embraced by park agencies around the world, but is one that requires park managers to approach conservation in new ways and to reassess traditional priorities with a landscape-scale perspective. National park wilderness is a key element in this new approach.

Key words
climate change impacts and adaptation, connectivity conservation, large landscape conservation, national parks, peace parks, transboundary conservation, wilderness, Yellowstone to Yukon

tional Park, Texas, to Boquillas del Carmen in Coahuila, Mexico (fig. 2; see also the Jarvis interview on pages 16–19).

As national park management thinking began to consider the areas around parks in the 1970s, transboundary conservation innovations such as the biosphere reserve and its cousin, the "greater ecosystem," emerged, driven by both research and observation. Parks with straight-line boundaries were increasingly viewed as insufficient to protect species that moved in and out of them to reach their seasonal ranges. Waterton-Glacier and other parks became UNESCO biosphere reserves. The Greater Yellowstone Ecosystem would become a widely known example, and by 1991, the phrase "Greater Yellowstone Ecosystem" had become an important organizing principle (Keiter and Boyce 1991).

The role of science, keystone species, and ecological conditions

Advancements such as international peace parks and biosphere reserves further situated national parks within a larger landscape, but the scale remained regional, such as the Rocky Mountains surrounding Yellowstone National Park, instead of the Northern Rocky Mountains extending into Canada. By the 1980s the insufficiency of this approach was highlighted by the emerging fields of island biogeography and conservation biology. In a seminal paper, Newmark showed that even America's largest national parks were islands of extinction that lost species over time and succumbed to the same ecological pressures that impact species on islands (1987). The solution proposed by conservation biologists was to take a larger perspective and to focus on much larger landscapes (Noss and Cooperrider 1994). Glacier National Park took an active interest in activities in Canada and talked of linkages northward to Banff and Jasper National Parks. By the end of the 20th century, conservation agencies around the world were starting to shift their thinking from managing individual parks to parks as integral components of a landscape network (Parks Canada Agency 2000).

Figure 2. U.S. Secretary of the Interior Ken Salazar (left) and Mexican Secretary of Environment Juan Elvira Quesada sign the Rio Bravo–Big Bend agreement on 24 October 2011 establishing an "area of binational environmental interest."

Of course, it is one thing to say that parks must be seen in a landscape context and another to know how to do that. Landscapes are inherently complex systems and large-scale approaches amplify this complexity. In an early approach, focal species were used as an organizing principle (Soule and Terborgh 1999). The Paseo Pantera Project, an idea of American ecologist Archie Carr III and Costa Rican Parks Service founder Mario Boza, considered the needs of cougars from Central America to Florida and called for linking up conservation reserves with movement corridors. Similarly, yet at an even larger scale, the Wildlands Project, an initiative of conservation biologists and activists, sought to consider the needs of a suite of species at the combined North and Central American scale (Soule and Terborgh 1999). Out of the same thinking, the Yellowstone-to-Yukon (Y2Y) Conservation Initiative emerged in 1993 (Locke 1994), seeking to link national parks and protected areas from Yellowstone National Park to the Yukon Territory to ensure the persistence of grizzly bears and the many species whose life needs would be met by landscapes maintained in a suitable condition (Locke 2006). Scientific studies increasingly took the perspective and supported the need for conservation of large mammals at the continental scale.

In the absence of keystone megafauna, other approaches to landscape-scale conservation have begun to unfold. In Australia a landscape connectivity approach has been developed that centers on ecological conditions (Mackey et al. 2010). Other efforts have also emerged, including the Great Eastern Ranges of Australia; the Terai Arc of India and Nepal; the Great Mountain Corridor in Spain, France, and Italy; and the Northern Appalachians of the United States and Canada (Worboys et al. 2010). Similar efforts in the marine realm can be seen in the large-scale approach to zoning the entire Great Barrier Reef of Australia. A global community of practice has emerged through the leadership of the Mountains Biome group of the International Union for the Conservation of Nature's (IUCN) World Commission on Protected Areas.

Large landscape conservation goes global

The Program of Work under the Convention of Biological Diversity, a 1992 treaty signed by 168 countries designed to prevent the loss of biodiversity around the world, recognizes the need for large landscape conservation (CBD 2005). At the ninth World Wilderness Congress (WILD 9), in Mérida, Mexico, senior representatives of five U.S. federal bureaus (National Park Service, USDA Forest Service, U.S. Fish and Wildlife Service, Bureau of Land Management, and USDA Office of Ecosystem Services and Markets), together with Parks Canada and the Mexican National Commission for Natural Protected Areas, signed a historical memorandum of understanding (MOU) on Cooperation for Wilderness Conservation (see Jarvis, pages 16–19). The initiative has moved ahead with support at the director level and the MOU was broadened in 2011 to include all protected areas.

A changing climate requires a landscape-scale response

The findings of conservation biology have required taking a large landscape conservation approach (Noss et al. *in press*), but it was the parallel emergence of the science behind climate change adaptation that solidified broad scientific consensus. Small-mammal studies in Yosemite National Park resurveying George Bird Grinnell's work nearly a century earlier record substantial movements of species due to changing climate (Moritz et al. 2008). Recent research shows species responding to climate change up to three times faster than previously known, shifting toward higher elevations at a median rate of 11.0 m (36.1 ft) per decade, and toward higher latitudes at a median rate of 16.9 km (10.5 mi) per decade (Chen et al. 2011). A comprehensive literature review found that connectivity was the single most frequently recommended method for allowing species to adapt to climate change (Heller and Zavaleta 2009). In another study the central role of core protected areas as anchors for any effort to adapt to climate change was highlighted (Hodgson et al. 2009). The authors stated four principles: (1) increasing protected areas, (2) maintaining and in some cases increasing environmental heterogeneity, (3) concentrating efforts in centers of endemism, and (4) reducing other pressures that are likely to be beneficial and robust, with or without climate change. This latter study of climate adaptation is important because it reminds us of the central role of national parks in any conservation strategy. Put another way, we need national parks *and* connectivity, and national parks should be managed to minimize human stressors, which can be accomplished by maximizing their wilderness character. It is important to remember that connectivity without robust core wilderness areas to connect to is like building a bridge to nowhere from nowhere.

A comprehensive literature review found that connectivity was the single most frequently recommended method for allowing species to adapt to climate change.

A scientific consensus

By the beginning of the second decade of the 21st century, the need to move from the national park level to the whole landscape had become a wide consensus. This was succinctly stated in a 2011 editorial in the British scientific publication *Nature*, entitled "Think Big": the best approach for park managers to take in the face of climate change is to think beyond their park and "to ponder instead the larger landscape in which their parks sit. Scaling up is reassuring. At the park level, climate change may extirpate a species. At the landscape level, climate change merely moves it" (Nature 2011, p. 131). This editorial also recognizes the key symbolism of Yellowstone National Park and the shift in thinking to the Y2Y scale: "Yellowstone remains the archetype for the park as an island. . . . As corridor ecology has taken off as a scientific subfield, so have corridor and connectivity projects such as the Yellowstone to Yukon Conservation Initiative in North America."

We need national parks* and *connectivity, and national parks should be managed to minimize human stressors, which can be accomplished by maximizing their wilderness character.

The complexities of working beyond boundaries

Study of the inherently complex mechanisms of how humans might organize themselves across international boundaries to accomplish large landscape conservation has become an area of academic interest (Chester 2006). In 2010 an international effort coordinated by the IUCN resulted in the creation of a volume of best connectivity conservation practices from around the world. In *Connectivity Conservation Management: A Global Guide* (Worboys et al. 2010) various case studies highlight the importance of a unified vision that guides all stakeholders, recognition that diverse stakeholders have diverse needs that should be accommodated as much as possible as long as the vision is achieved and that different kinds of land tenures require different conservation tools, and the importance of recognizing that such work is inherently long-term. In 2011 the Lincoln Institute on Land Policy issued a case study of North American efforts and considered their future (Levitt and Chester 2011) and is hoping to develop a North American community of large landscape conservation practice.

Taking on this complexity may seem daunting but it is essential to ensuring resilient ecosystems. The Intergovernmental Panel on Climate Change stated, "the resilience of many ecosystems is likely to be exceeded this century by an unprecedented combination of climate change, associated disturbances (e.g., flooding, drought, wildfire, insects, ocean acidification), and other global change drivers (e.g., land use change, pollution, overexploitation of resources)" (Parry et al. 2007, N 4.1 to 4.6). The best and most hopeful response park managers can use to address this profound challenge to ecosystems in the 21st century is to embrace and implement large landscape conservation.

A mandate to park managers

America's Great Outdoors, the 2011 report to President Obama on U.S. federal lands, recognizes the importance of large landscape conservation and instructs federal agencies to work together to achieve it. A natural evolution of America's greatest idea, the national park, would require park managers and scientists to think about priorities at a larger scale and in new ways. In its August 2011 publication of *A Call to Action*, the National Park Service acknowledges the importance of large landscape conservation as essential to achieving its mission in the 21st century as follows: "To preserve America's special places in the next century the NPS must manage the natural and cultural resources of the National Park System to increase resilience in the face of climate change and other stressors, cultivate excellence in science and scholarship as a foundation for park planning, policy, decision-making … [and] collaborate with other land managers and partners to create, restore and maintain landscape scale connectivity."

What does all this mean in an applied way for national park managers? New scales must be considered and new questions must be asked and answered: Is it more important to study a species' behavior inside the park or to support research into the understanding of how the species navigates the whole landscape now and how it is likely to do so in the future? Is it more critical to acquire the last 100-year-old inholding inside a national park or to purchase private lands in key linkage areas outside the park so that park species can move securely in the future? Should we study the role of aquatic insects in feeding a park's trout population or instead investigate how gravel bed river systems as a whole function in order to develop and implement regional conservation strategies that will help us adapt to climate change so we can maintain coldwater species like trout? Can park managers change their workweek to spend time with neighbors to promote a clear vision of large landscape conservation for their regions and help to create and enable coordinated conservation efforts across jurisdictions at scale? Can park managers identify culturally effective ways to communicate to park visitors and neighbors the critical role of national parks and wilderness as the centerpiece of large-scale integrated conservation efforts?

Large landscape conservation across boundaries requires collaborative conservation at the regional, national, and international levels. Not all of this is in the control of park managers. But one thing is: in this rapidly changing world, national park wilderness will remain the gold standard for all conservation actions and will be at the heart of the large landscape conservation efforts that have the best chance of success.

Acknowledgments

I thank Dr. Gary Tabor and Dr. Ric Hauer for their constructive comments on this article.

References

Ali, S. H. 2007. Peace parks: Conservation and conflict resolution. MIT Press, Cambridge, Massachusetts, USA.

Chen, I.-C., J. K. Hill, R. Ohlemüller, D. B. Roy, and C. D. Thomas. 2011. Rapid range shifts of species associated with high levels of climate warming. Science 333(6045):1024–1026. doi: 10.1126/science.1206432.

Chester, C. 2006. Conservation across borders: Biodiversity in an interdependent world. Island Press, Washington, D.C., USA.

Convention on Biological Diversity (CBD). 2005. Programme of work. Decision VII/28. Accessed 1 December 2011 from http://www.cbd.int/decision/cop/?id-7765.

Heller, N. E., and E. Zavaleta. 2009. Biodiversity management in the face of climate change: A review of 22 years of recommendations. Biological Conservation 142:14–32.

Hodgson, J. A., C. D. Thomas, B. A. Wintle, and A. Moilanen. 2009. Climate change, connectivity and conservation decision making: Back to basics. Journal of Applied Ecology 46(5):964–969. doi:10.1111/j.1365-2664.2009.01695.x.

Keiter, R. B., and M. Boyce. 1991. The Greater Yellowstone Ecosystem: Refining America's wilderness heritage. Yale University Press, New Haven, Connecticut, USA.

Konstant W., H. Locke, and J. Hanna. 2005. Waterton-Glacier International Peace Park: The first of its kind. *In* R. A. Mettermeier, C. F. Kormos, C. G. Mittermeier, P. R. Gil, T. Sandwith, and C. Besançon, editors. Transboundary conservation: A new vision for protected areas. Cemex–Agrupacion Sierra Madre–Conservation International, Mexico DF, Mexico.

Levitt, J. N., and C. C. Chester. 2011. The future of large landscape conservation in America. Lincoln Institute of Land Policy, Cambridge, Massachusetts, USA.

Locke, H. 1994. Preserving the wild heart of North America: The Wildlands Project and the Yellowstone to Yukon Biodiversity Strategy. Borealis (15):18.

———. 2006. The need and opportunity for landscape scale conservation in the Yellowstone to Yukon region: A vision for the 21st century. Pages 99–108 *in* A. Wondrak-Biel, editor. Greater Yellowstone public lands: A century of discovery, hard lessons, and bright prospects. Proceedings of the 8th Biennial Scientific Conference on the Greater Yellowstone Ecosystem. Yellowstone Center for Resources, Yellowstone National Park, Wyoming, USA. Available from http://www.nps.gov/yell/naturescience/8thconferenceproceedings.htm.

———. 2009. Civil society and protected areas: Lessons from Canada. The George Wright Forum 26(2), Hancock, Michigan, USA.

Locke, H., and M. McKinney. *In press*. Flathead Valley Flashpoint. Chapter 10 *in* E. S. Norman, A. Cohen, and K. Bakker, editors. Water without borders: Canada, the U.S. and transboundary water. University of Toronto Press, Toronto, Ontario, Canada.

Mackey, B., J. Watson, and G. L. Worboys. 2010. Connectivity conservation and the Great Eastern Ranges corridor. ANU Enterprises Pty Ltd, Department of Environment, Climate Change and Water, New South Wales, Sydney, Australia.

Moritz, C., J. L. Patton, C. J. Conroy, J. L. Parra, G. C. White, and S. R. Beissinger. 2008. Impact of a century of climate change on small-mammal communities in Yosemite National Park, USA. Science 322(5899):261–264. doi: 10.1126/science.1163428.

National Park Service (NPS). 2011. A call to action: Preparing for a second century of stewardship and engagement. Washington, D.C., USA. Available from http://www.nps.gov/CallToAction.

Nature. 2011. Think big. Nature 469:131. doi: 10.1038/469131a.

Newmark, W. 1987. A land bridge island perspective on mammalian extinctions in western North American national parks. Nature 325:430–432.

Noss, R. F., and A. Y. Cooperrider. 1994. Saving nature's legacy: protecting and restoring biodiversity. Island Press, Washington, D.C., USA.

Noss, R. F., A. Dobson, R. Baldwin, P. Beier, D. DellaSala, J. Francis, H. Locke, K. Nowak, R. R. Lopez, C. Reining, S. Trombulak, and G. Tabor. *In press*. Bolder thinking for conservation. Conservation Biology 26.

Parks Canada Agency. 2000. Unimpaired for future generations? Protecting ecological integrity with Canada's national parks. Volumes 1 and 2. Report of the Panel on the Ecological Integrity of Canada's National Parks, Ottawa, Ontario, Canada.

Parry, M. L., O. F. Canziani, J. P. Palutikof, P. J. van der Linden, and C. E. Hansen. 2007. Climate change 2007: Impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK.

Roosevelt, T. 1994. The strenuous life. Pages 184–189 *in* M. R. Di Nunzio, editor. Theodore Roosevelt, an American mind: Selected writings. Penguin, New York, New York, USA.

Salazar, K., T. J. Vilsak, L. P. Jackson, and N. H. Sutley. 2011. America's great outdoors: A promise to future generations. Report. U.S. Government Printing Office, Washington, D.C., USA. Available from http://americasgreatoutdoors.gov/report.

Soule, M., and J. Terborgh. 1999. Continental conservation: Scientific foundations of regional reserve networks. The Wildlands Project and Island Press, Washington, D.C., USA.

Worboys, G., W. L. Francis, and M. Lockwood, editors. 2010. Connectivity conservation management: A global guide. Earthscan, London, UK.

About the author

Harvey Locke *is strategic conservation advisor at the WILD Foundation, strategic advisor for the Yellowstone to Yukon Conservation Initiative, senior advisor for Conservation for the Canadian Parks and Wilderness Society, and a member of IUCN's World Commission on Protected Areas.*

PS

Integrating cultural resources and wilderness character

By Jill Cowley, Peter Landres, Melissa Memory, Doug Scott, and Adrienne Lindholm

USFS/PETER LANDRES

CULTURAL RESOURCES ARE AN INTEGRAL PART OF WILDER-ness and wilderness character. Not all those involved in the preservation and appreciation of wilderness agree with this statement. Varying perspectives derive from a basic difference in belief about the relationship between humans and the nonhuman world—whether or not humans are a part of nature. For some, wilderness means pristine nature and the absence of human modification, where the presence of ancient dwellings, historic sites, or other signs of prior human use degrades wilderness. For others, wilderness is a cultural landscape that has been valued, used, and in some areas modified by humans for thousands of years (fig. 1). Reconciling these perspectives can be difficult.

To foster this reconciliation, the National Park Service (NPS) National Wilderness Steering Committee (now the Wilderness Leadership Council) stated that "National Park Service policies properly and accurately incorporate cultural resource stewardship requirements into the management standards for wilderness areas" (National Wilderness Steering Committee 2002). Likewise, in her 2011 draft white paper, Laura Kirn (National Park Service, branch chief, Anthropology, Yosemite National Park) discusses the philosophical perspectives as well as agency practices and implications of recent court cases that have led to what is perceived as a divide between cultural resources and wilderness. She notes, however, that according to historical research and policy, the two camps need not be divided.

Our position is that cultural resources—archaeological sites, ethnographic resources, cultural landscapes, and historical structures and sites—are components of wilderness areas and may contribute positively to wilderness character. In addition to preserving ecosystems, wilderness helps us understand human use and value of the land over time. One of the fundamental purposes of cultural resources is to promote multiple views of history, and wilderness can also be valued from multiple viewpoints.

NPS/STERLING HOLDORF

Figure 1. (Above) Ancestral Puebloan cliff dwellings in Johns Canyon, Grand Gulch Wilderness, Utah. (Right) Historic preservationists complete work on the Agnes Vaille Shelter historic structure at the Keyhole on Longs Peak, Rocky Mountain National Park Wilderness, Colorado.

Abstract
Cultural resources are an integral part of wilderness and wilderness character, and all wilderness areas have a human history. This article develops a foundation for wilderness and cultural resource staffs to continue communicating with one another in order to make better decisions for wilderness stewardship. Following a discussion of relevant legislative history, we describe how cultural resources are the fifth quality of wilderness character. Examples of how cultural resources in wilderness are being managed in a variety of parks include working with tribes to manage ethnographic resources in wilderness and using the Minimum Requirements Analysis to determine the appropriateness of historic preservation actions and activities. The article closes with three recommendations to help parks address managing cultural resources in wilderness in the future.

Key words
archaeological resources, cultural landscapes, cultural resources, ethnographic resources, historic structures, wilderness, wilderness character

For example, a wilderness trail may reflect centuries of use by hunters, traders, miners, settlers, and travelers; today this same trail is used by wilderness visitors and represents a merging of past and present. Ecologically, while past human presence may not be apparent on a landscape, "the legacies of historic land-

use activities continue to influence the long-term composition, structure, and function of most ecosystems and landscapes for decades and centuries after the activity has ceased" (Wallington et al. 2005; also see Foster et al. 2003). All wilderness areas have a human history.

In this article, we offer a perspective that promotes human history as integral to wilderness. Specifically, our intent is fourfold: (1) to enhance mutual understanding and respect between the cultural resources and wilderness communities; (2) to review relevant legislation and policy, the concept of wilderness character, and Minimum Requirements Analysis as they relate to cultural resources and wilderness; (3) to provide park examples of how cultural resources are being managed within wilderness; and (4) to recommend future actions. Several important related topics are not within the scope of this short article. We defer to others to provide legal responses to recent court cases that have raised questions about cultural resource management in wilderness (e.g., *Olympic Park Associates v. Mainella* [2005]). We do not offer specific tools to reconcile difficult cases; rather, our purpose is to develop a foundation for wilderness and cultural resources staffs to talk with each other and to make better decisions that respect all park values.

Legislative history

Wilderness legislation and legislative history strongly support integrating cultural resources with wilderness. The initial 1956 version of the Wilderness Act specifically listed units of the National Park System within which wilderness was to be designated. This list included Shenandoah (Virginia) and Great Smoky Mountains (Tennessee and North Carolina) National Parks, which have a history of extensive habitation by settlers, and Mesa Verde National Park (Colorado), with its abundance of archaeological resources. The 1964 Wilderness Act includes historical value in the list of associated wilderness values, and explicit in Section 4(a)(3) is that nothing in the Wilderness Act should lower the standards of preservation of the 1916 National Park Service Organic Act, the 1906 American Antiquities Act, and the 1935 Historic Sites Act. Further, the legislative record and wilderness acts subsequent to the 1964 act clearly indicate congressional intent to include cultural resources as part of the overall wilderness resource.

The 1976 Wilderness Designation Act established wilderness areas in a number of national park units and included "historic preservation" in the list of wilderness values and opportunities. Bandelier Wilderness, in Bandelier National Monument (New Mexico), was established by this 1976 act, partly to protect the archaeological resources occurring therein. The 1994 California Desert Protection Act added significant acreage to Death Valley National Park, establishing about 91% of the park as wilderness and directing the park to protect and preserve "historical and cultural values of the California desert associated with ancient Indian cultures, patterns of western exploration and settlement, and sites exemplifying the mining, ranching, and railroading history of the Old West." Many resources related to these themes are located in wilderness.

In addition, national wilderness advocates like the Wilderness Society, who worked closely with members of Congress who championed the Wilderness Act, had a fundamental commitment to the standing of historical and cultural features among the purposes for which wilderness areas were established. Their understanding of wilderness included both the value of specific cultural features protected within a wilderness and the cultural significance of the overall environment of the wilderness (Zahniser 1956).

The Wilderness Act and the National Historic Preservation Act

Wilderness and cultural resources are protected and preserved by federal legislation, primarily the 1964 Wilderness Act and the 1966 National Historic Preservation Act (the NHPA), as amended, respectively. Both acts share similar reasons for protecting wilderness and cultural resources. The Wilderness Act states that wilderness is established to preserve it from "an increasing population, accompanied by expanding settlement and growing mechanization." Similarly, the NHPA states that cultural resources need protection from "ever-increasing extensions of urban centers, highways, and residential, commercial, and industrial developments." Neither law states that it trumps the other, and thus federal agencies must equally uphold both laws and the values they embody.

Park examples clarify this relationship. Bandelier National Monument balances the enabling proclamations and legislation for the monument and the NHPA, which call for protecting archaeological resources, with the 1964 Wilderness Act and the 1976 Wilderness Designation Act designating the Bandelier National Monument Wilderness. Archaeological resources in the wilderness are being degraded by erosion, and the park is pursuing ecological restoration in wilderness to slow erosion and protect cultural resources (National Park Service, B. Judy, chief of Resources Management, Bandelier National Monument, personal communication, 5 July 2011; National Park Service, S. Stutzman, wilderness coordinator, Intermountain Region, personal communication, 5 July 2011; Sydoriak et al. 2000). The system of backcountry trails constructed by the Civilian Conservation Corps (CCC) in the 1930s in Chiricahua National Monument (Arizona) (fig. 2) is

contained in the Chiricahua Wilderness (fig. 3) and also within the monument-wide historic district. These trails, with their historic retaining walls and other related historic structures, are considered to be part of the area's wilderness character because they were an integral part of the landscape for many years prior to wilderness designation (National Park Service, J. Curtis, chief of Facility Management, Chiricahua National Monument, personal communication, 5 July 2011). The trails and related structures are being maintained to protect their historic character and wilderness character (National Park Service, S. Stutzman, wilderness coordinator, Intermountain Region, personal communication, 5 July 2011).

If cultural resources are specifically mentioned in wilderness legislation as a reason for the area's designation as wilderness, those resources can be included as part of the area's wilderness character. For example, some mining structures in Death Valley Wilderness may now be considered part of the character of this wilderness as a symbol of past human relationships with the land (National Park Service, C. Callagan, wilderness coordinator, Death Valley National Park, personal communication, 5 July 2011). If cultural resources are not specifically mentioned in wilderness legislation, the park, responding to the National Historic Preservation Act, may still preserve those resources and consider them an integral part of wilderness character. For example, Olympic National Park's wilderness legislation does not specifically address cultural resources, but the park's general management plan is purposeful in including management of cultural resources in wilderness (National Park Service, R. Scott, natural resource specialist, Olympic National Park, personal communication, 8 August 2011).

NPS/VICTORIA JACOBSON

Figure 2. Historical CCC trail in the Chiricahua National Monument Wilderness, Arizona.

Cultural resources and wilderness character

The article "Using wilderness character to improve wilderness stewardship" (this volume, pages 44–48) describes the development and use of five qualities of wilderness character that are tangible and link local conditions and management directly to the statutory language of the Wilderness Act. Four of these qualities (natural, solitude or primitive and unconfined recreation, undeveloped, untrammeled) apply to every wilderness regardless of size, location, agency administration, or any other attribute, and apply to the entire area within a wilderness. The fifth quality, *other features*, is based on the last part of Section 2c, "Definition of Wilderness," in the Wilderness Act, that a wilderness "may also contain ecological, geological, or other features of scientific, educational, scenic, or historical value." This fifth quality, unlike the other four, is unique to an individual wilderness based on the

NPS/JILL COWLEY

Figure 3. Chiricahua Wilderness view from Massai Point, Chiricahua National Monument.

features that are inside that wilderness, and these features typically occur in specific locations rather than throughout the entire wilderness. Cultural sites clearly fit within this fifth quality of wilderness character because they are tangible features that have scientific, educational, scenic, and historical value. The historic structures in Death Valley Wilderness that are discussed above, for example, would be included in this fifth quality.

All five tangible qualities of wilderness character combine to form a setting that is unique to each wilderness, and this setting may confer important values that are not directly part of wilderness character, but are derived from this setting. For example, aspects of cultural resources, such as spiritual values, traditional practices, and traditional and historic stories (Cronon 2008), are important and vital for understanding culture and place, but are purposefully not integrated with wilderness character for several reasons. First, they typically derive from a time before the Wilderness Act and the concept of wilderness character. Second, they may not be tangible, and should not be forced into such a mold. Third, they may be closely held and cherished, and not meant to be shared with others.

Whether historic structures, sites, and landscapes in wilderness should be preserved, left to molder, or removed continues to be debated. "It is vital for local wilderness staff and cultural resources staff, using both the Wilderness Act and cultural resource protection laws, to work together and develop a common understanding" (Landres et al. 2008) of how historical resources should be managed. Section 110 of the National Historic Preservation Act requires that the National Park Service survey and inventory all historical resources, including those in wilderness, and Section 106 requires federal agencies to consider effects of actions on historical resources. National Park Service policy states that potentially eligible historical resources will be managed as if listed on the National Register of Historic Places (the Register) until they are determined not to be eligible. Register status influences decisions about whether or not cultural resources in wilderness are actively preserved. This decision may also be influenced by the location, visibility, and interpretive potential of the resource. For example, in the recommended wilderness in Dinosaur National Monument (Colorado), the park decided to stabilize a wilderness cabin because of its interpretive value (National Park Service, M. Risser, superintendent, Dinosaur National Monument, personal communication, 5 July 2011; National Park Service, W. Prokopetz, chief of Resources Management, Dinosaur National Monument, personal communication, 5 July 2011), even though it was determined to be ineligible for the Register.

A number of parks are developing a wilderness character narrative that describes what is unique and special about the area (e.g., Lake Clark National Park [Alaska], Gates of the Arctic National Park and Preserve [Alaska], Everglades National Park [Florida], Guadalupe Mountains National Park [Texas]). These narratives integrate historical and ethnographic resources and values with wilderness character, setting the context for planning and decisions about wilderness stewardship. For example, at Lake Clark National Park and Preserve, the planning area for the General Management Plan Amendment (which also meets the requirements of a Wilderness Stewardship Plan) includes hundreds of known cultural resources, thousands of Dena'ina and Yup'ik place-names, and innumerable unknown and undocumented cultural resources. These cultural sites illustrate the significant relationship of past and present people to this area. The wilderness character narrative describes some historical cabins and archeological sites as part of the five tangible and measurable qualities of wilderness character that provide the setting from which additional cultural values are derived. Park staff felt that the most important of these is the connection the Dena'ina people have to Lake Clark Wilderness and the role it has played in shaping the Dena'ina culture. The park chose to include an essay at the end of the narrative that recognizes and celebrates this vital connection.

In addition to preserving ecosystems, wilderness helps us understand human use and value of the land over time. One of the fundamental purposes of cultural resources is to promote multiple views of history, and wilderness can also be valued from multiple viewpoints.

Cultural resources management and minimum requirements analysis

The Minimum Requirements Analysis process can determine whether a historic preservation action is necessary and appropriate in wilderness, and if so, determine the minimum activity to accomplish that action. The analysis must consider different potential impacts on wilderness character of different methods for accomplishing a project (National Park Service, R. O'Neil, Plateau District ranger, Zion National Park, personal communication, 5 August 2011).

Types of equipment and method of access to the project site are two aspects of historic preservation projects that may need to be modified for work in wilderness. For example, the Taylor Creek cabins in Zion National Park (Utah) contribute to interpretation and understanding of pioneer use and occupation in what is now wilderness. Preserving this historical resource required structural stabilization of a cabin and a corral, and fuels assessment and clearing understory fuels around structures. A Minimum Requirements Analysis determined that the use of hand tools (including historical and pre-contact tools), a small work crew, and use of local resources (dead trees within 100 meters [305 ft] of the site) were the minimum activities (National Park Service, S. Horton, chief of Cultural Resources, Zion National Park, personal communication, 5 July 2011; National Park Service, S. Stutzman, Intermountain Region wilderness coordinator, personal communication, 2 August 2011). In the recommended wilderness at Arches National Park (Utah), preservation of a historic stone cabin involved access over a slickrock route, no backcountry camp, reducing work crew size, collecting mortar soil from multiple locations, and raking out the soil collection sites and footprints, as determined in the Minimum Requirements Analysis (National Park Service, C. Goetze, Cultural Resource Program manager, Southeast Utah Group, personal communication, 5 July 2011). Using traditional skills, methods, tools, and material benefits both historic preservation and wilderness character, and can benefit the long-term perpetuation of these skills.

Some situations may be contentious, but even here the Minimum Requirements Analysis is the means for systematic, comprehensive, transparent, and defensible decisions. For example, in the 7.2 million–acre (2.9 million ha) Gates of the Arctic Wilderness, in Gates of the Arctic National Park and Preserve (Alaska), the park determined the use of helicopters to be the minimum activity for conducting legislatively required NHPA Section 110 cultural resource inventories in this extremely large and remote area (National Park Service, J. Rasic, archaeologist, Yukon-Charley Rivers/Gates of the Arctic National Parks and Preserves, personal communication, 2 August 2011).

Tribal perspectives on wilderness

As this article suggests, tribal perspectives on wilderness are also important to consider. Tribal issues and concerns related to wilderness require a more detailed discussion than can be included here. Many areas today identified as wilderness have been, and continue to be, important to the traditional beliefs and lifeways of Native American tribes: they serve as hunting areas, plant gathering areas, and places associated with ceremony and spiritual sustenance. Tribal concerns may relate to cultural or natural resources, and may include maintaining access to sacred sites and reburials within wilderness, and maintaining the ability to propagate and collect ceremonial resources, such as specific plant materials, within wilderness. Tribal members may also have traditional knowledge of wilderness resources that can assist management. Consulting with tribes on potential wilderness management strategies is key.

Future needs

From the foundation discussed in this article, future efforts can continue to build specific ways to address and resolve issues of managing cultural resources in wilderness. We recommend the following steps:

1. Further development of tools parks can use to help them decide which cultural resources in wilderness to manage actively, why, and with what activities and methods. Some of these tools are already available, such as the Arthur Carhart National Wilderness Training Center's online course "Managing Cultural Resources in Wilderness."

2. Further development of tools for parks to help them integrate cultural resources within wilderness character.

3. Guidance on how to address cultural resources as part of wilderness character within the park planning process.

Despite the challenges, the NPS resources management community can continue working together to negotiate differences in management approaches. Wilderness proponents and cultural resource staff can collaborate to achieve their respective goals. By working together and improving communication and understanding, we can enhance the preservation of integrated natural and cultural heritage in wilderness and the values and meanings of this heritage to our society.

Acknowledgments

Thanks go to those who supplied material for the examples and reviewed drafts (Barbara Judy, Charlie Callagan, Chris Goetze, Christine Landrum, Jeff Manley, Jeremy Curtis, Leah Bonstead, Mary Risser, Ray O'Neil, Sandee Dingman, Sande McDermott, Sarah Craighead, Sarah Horton, Suzy Stutzman, Ted Birkedal, and Wayne Prokopetz). Thanks also go to members of the NPS Cultural Resources Advisory Group and the Wilderness Leadership Council for their feedback.

CONTINUED ON PAGE 38 >>

Climate change: Wilderness's greatest challenge

By Nathan L. Stephenson and Constance I. Millar

SOME 20,000 YEARS AGO, THE AREA THAT WE NOW know as the Marjory Stoneman Douglas Wilderness in Everglades National Park (Florida) was not graced by the sprawling "river of grass," dense mangrove forests, and the rich waters of the Florida Bay. With a sizable amount of Earth's water locked up in continental ice caps, the present bay was high and dry, the nearest ocean shore was miles away, and the land supported pine woodlands and scrub. On the other side of the continent, the parched salt flats of today's Death Valley Wilderness (California) were drowned under a 600-foot-deep (183 m) lake. The Yosemite Wilderness's (California) stately forests, lush meadows, and high mountain lakes were buried under hundreds of feet of ice.

What a difference a few degrees can make! The dramatic changes described in the preceding paragraph accompanied a Pleistocene-to-the-present global warming of about 4° to 7°C (Jansen et al. 2007). Yet Earth is now poised to undergo another round of warming of comparable magnitude. Current projections indicate that a further 4° to 6°C global warming could be reached by as early as the end of this century (IPCC 2007), when global temperatures could exceed any reached in the last several million years. Earth has already gained about 0.6°C since 1975, and the pace of warming is expected to accelerate. Even the relatively modest warming so far has affected hydrology, fire regimes, and biota in national parks and wildernesses (Gonzalez 2011). The message is clear: In the coming decades wilderness seems certain to face its greatest stewardship challenge yet, in the form of profound climatic and other global changes.

Wilderness stewards must determine how best to respond to this greatest of challenges, and the goal of this article is to help them by offering relevant ideas and provoking discussion. First, we briefly reexamine the Wilderness Act in the light of rapid climatic changes, and conclude that stewards will be forced to confront trade-offs that were not anticipated by the act's authors—trade-offs that will be accompanied by increasing impetus for management intervention in wilderness. Next, we briefly outline four broad classes of management actions (or inaction) that wilderness stewards might consider in their efforts to adapt to a rapidly changing climate. Finally, we highlight some considerations for planning in the face of rapid climatic changes.

Abstract

Anthropogenic climatic change can no longer be considered an abstract possibility. It is here, its effects are already evident, and changes are expected to accelerate in coming decades, profoundly altering wilderness ecosystems. At the most fundamental level, wilderness stewards will increasingly be confronted with a trade-off between untrammeled wilderness character and primeval, natural conditions, accompanied by increasing impetus for management intervention. Possible strategic responses to climatic change fall into four broad classes: restraint (do nothing), resilience, resistance (near-term ways of buying time), and realignment (long-term adaptation). Planning responses will be made challenging by the unprecedented and unpredictable nature of future changes; fortunately, robust planning approaches, like scenario planning, are available.

Key words

climate change, global changes, resilience, trade-offs, Wilderness Act, wilderness character, wilderness planning

The Wilderness Act in the era of rapid climatic changes

The Wilderness Act of 1964 famously defines the idealized concept of wilderness as an area where Earth and its community of life are "untrammeled by man," with "untrammeled" meaning unrestrained, self-willed, and allowed to run free (Landres et al. 2008). However, the authors' careful choice of the term "untrammeled" was underlain by a critical assumption: that for generations to come Earth's environment would be inherently stable within its historically observed bounds of variation. The dominant thinking of the era had not yet awakened to the onset of rapid, human-induced, boundary-transcending global changes. The term "untrammeled" in the act thus primarily referred to an absence of *intentional* human influences, as was neatly encapsulated by one of the authors' pleas that humans act as "guardians not gardeners" of wilderness (Zahniser 1963).

If untrammeled was meant to refer to an absence of intentional human influences, what are we to make of pervasive *unintentional* human influences, like anthropogenic climatic change? Imagine

the following scenario—the sort of scenario that seems likely to play out with increasing frequency in the future:

> With rising temperatures and earlier snowmelt, a forested wilderness experiences a massive crown fire well outside of the range of historical fire behavior. Most of the local seed sources are killed, and subsequent rains cause extensive erosion. Rising temperatures and soil loss preclude the reestablishment of continuous forest cover, and the wilderness is colonized by shrubs and an array of nonnative invasive grasses and forbs adapted to disturbed sites.

This wilderness remains untrammeled in the sense that its new condition is not a consequence of intentional human influences. But does it remain untrammeled simply because the massive changes ultimately were the consequence of unintentional human influences (anthropogenic climatic changes and introductions of nonnative invasive species)? If, in an alternative scenario, wilderness managers had intentionally thinned the forest, enabling it to survive the fire relatively intact, would the resulting forest have less wilderness character than the eroded shrubland of the first scenario?

These sorts of questions are not new (e.g., Sydoriak et al. 2000), and we will never know how the framers of the Wilderness Act would have addressed them. But hints are embedded in the second sentence of the act's definition of wilderness, which was intended to provide a more pragmatic definition of wilderness areas (Scott 2002): areas that retain their "primeval character and influence" and that are "protected and managed so as to preserve [their] natural conditions." The terms "primeval" and "natural" usually carry a sense of historical fidelity—conditions that fall within the bounds that occurred in the centuries preceding the influences of modern technological society. At the time of the act's passage it would have been normal to assume that a protected (untrammeled) landscape would necessarily express a high degree of historical fidelity, so the two ideas usually were conflated. We now know this assumption is false, and we must explicitly consider the relationship between untrammeled quality and historical fidelity (e.g., Aplet and Cole 2010).

In the future, trade-offs between these two strongly defining characteristics of wilderness—untrammeled quality and historical fidelity (primeval and natural character)—will be inevitable. Climatic and other global changes will increasingly act to erode historical fidelity, as in the forest scenario presented above. But any efforts to maintain critical and sometimes legally protected aspects of historical fidelity—such as native biodiversity and key ecosystem functions like hydrologic regulation—will require increasing management intervention (trammeling). When this trade-off is assessed in light of rapidly accelerating global changes, it seems inevitable that reasons to intervene in wilderness will increase through time.

Classes of actions to consider

Appropriate management actions in anticipation of (or in response to) rapid climatic changes will vary widely among wilderness areas, and in many cases will need to be founded on careful, site-specific thought and research, well beyond the scope of this article. However, it is useful to think of the spectrum of possible management actions as falling into four broad classes that include the more familiar "three Rs"—resilience, resistance, and realignment (Millar et al. 2007)—plus a "fourth R" that is particularly relevant to wilderness—restraint. We begin with restraint.

Restraint (leave some places alone). For reasons well articulated by Landres (2010) and others, wilderness stewards usually should be (and usually are) very wary about intervening in wilderness. Yet for other well-articulated reasons, management interventions do occur in wilderness (Sydoriak et al. 2000; Cole et al. 2008), and expected climatic changes seem sure to increase the impetus to intervene. Yet even if managers decide they have good reason to intervene in a particular wilderness, the realities of limited staffing, funds, and access will usually mean that interventions can occur only in relatively small, strategically chosen parts of a wilderness landscape, focused on resources of particularly high value and vulnerability (such as a popular grove of giant sequoias or an endangered species). Thus, by default, large parts of the landscape will remain untrammeled, in the strict sense of lacking intentional human influences. In those rare cases when managers might have the ability to affect every part of a wilderness landscape, strong consideration should be given to restraint—selecting certain areas in which no interventions will occur (Landres 2010). The remaining "three Rs," described below, therefore will usually apply only to limited, high-value parts of a wilderness that are strategically selected for intervention. The first two classes of actions, resilience and resistance, are perhaps best considered as near-term actions.

Resilience (enhance ecosystem resilience). Resilience is an ecosystem's ability to absorb a stress without flipping into an entirely new state, such as from forest to eroded shrubland. Of all possible near-term actions wilderness stewards can take, maintaining or increasing resilience is one of the most important. Resilience should not be viewed as an end in itself. Rather, it is a means of buying time while (1) wilderness stewards, policymakers, and the public more carefully assess the policy and management implications of climatic changes for wilderness, and (2) wilderness stewards and researchers develop and test possible long-term adaptive responses. Actions that maintain or increase

resilience might include, for example, strategically controlling selected nonnative invasive species and thinning forests.

Resistance (resist changes). Resistance can be a property of an ecosystem itself, but here we use it to refer to management actions designed to resist change (e.g., Millar et al. 2007). Like enhancing ecosystem resilience, in the near term resistance can provide a critical means of buying time. Resistance might include intensive actions taken to protect an endangered species, such as creating fuel breaks to diminish the probability of severe wildfire, controlling a tree-killing beetle outbreak, or keeping an endangered plant population healthy by drip irrigation.

In the long term, climatic changes are likely to be so large that most strategies focusing only on resilience and resistance eventually will fail, perhaps catastrophically. But the value of a near-term focus on resilience and resistance is that it can buy us valuable time while we seek long-term strategies for the final R, realignment.

Realignment (facilitate changes). In the long term, maintenance of native biodiversity and key ecosystem functions into the future may be most successful if wilderness stewards actively facilitate change. A few examples illustrate facilitation. If a species is unable to migrate fast enough to keep up with geographic shifts in suitable habitat, physically moving the species—assisted migration—might sometimes be appropriate, especially if the alternative is losing the species entirely. Following a major disturbance, it may be appropriate to plant an area with species better adapted to warmer conditions. Finally, adaptive potential of some species might be increased by purposefully mixing genotypes from other regions. Of course, any one of these actions would demand deep forethought and extreme caution, and depending on site-specific context might be rejected as undesirable.

Planning considerations

Implementation of any of these classes of strategic management actions must be preceded by careful planning, but planning for a changing climate presents some unique challenges. We offer the following ideas for consideration.

The past may no longer provide a useful target for the future. The profound Pleistocene-to-the-present landscape transitions described earlier give us a feel for the magnitude of changes wilderness could face by the end of this century. Wilderness will also be affected by an array of other novel anthropogenic global changes, such as pollution, altered disturbance regimes, habitat fragmentation, and nonnative invasive species. Collectively, these changes mean that our world has entered an era in which keystone environmental drivers—those that define the possible range of characteristics of a wilderness area—simply have no analog in the past, no matter how distantly we look (Saxon et al. 2005; Stephenson et al. 2010). An important consequence is that historical wilderness conditions will no longer automatically provide a useful target for restoring or maintaining wilderness ecosystems (Millar et al. 2007; Stephenson et al. 2010). While wilderness stewards will almost certainly want to maintain certain broad aspects of historical fidelity (such as native biodiversity and key ecosystem functions), attempts to maintain precise historical fidelity will almost certainly need to be abandoned.

Familiar planning approaches may become ineffective. At the scales, accuracy, and precision most useful to wilderness stewards, the future promises to be not only unprecedented but also unpredictable. Model projections can help us envision the possible nature and magnitude of future landscape changes, but such projections carry large uncertainties and therefore cannot be used as precise predictions (Stephenson et al. 2010). A corollary is that surprises are inevitable. A critically important class of surprises is threshold events, in which gradual environmental changes eventually trigger sudden, dramatic, and sometimes irreversible changes in ecosystem conditions (Scheffer and Carpenter 2003); for example, in parts of western North America gradual warming has contributed to sudden and extensive outbreaks of bark beetles, killing large swaths of forest. A consequence of uncertainty is that familiar planning approaches, which usually assume we either know the future or can accurately predict it, are likely to become ineffective (Weeks et al. 2011).

Use planning approaches that consider a broad array of possible futures. In the face of such uncertainty, the most useful planning approaches may be those that seek to identify management actions that are likely to succeed under a broad array of possible future conditions. Such approaches include scenario planning and its relatives (Nydick and Sydoriak 2011; Weeks et al. 2011). All planning efforts will likely benefit from considering scenarios that include abrupt threshold changes.

Define undesired future conditions. Another consequence of the unprecedented and unpredictable future is that the familiar planning approach of defining relatively precise desired future conditions is likely to become less effective. Instead, planning efforts might benefit from including explicit definitions of undesired future conditions—conditions to be avoided. For example, undesired future conditions might include loss of native biodiversity or critical ecosystem functions. A broad array of future wilderness conditions might be deemed acceptable as long as they do not fall within the undesired future conditions.

Our world has entered an era in which keystone environmental drivers—those that define the possible range of characteristics of a wilderness area—simply have no analog in the past, no matter how distantly we look.

Plan appropriate responses before abrupt changes occur. Sudden threshold changes can effectively denude large portions of a wilderness landscape in a matter of a few years, months, or in the case of fire, days or hours. While we cannot predict exactly how or when such transformations will occur, we can predict with high confidence that their frequency and severity will increase in the future. Possible management responses—such as erosion control or planting native species that are better adapted to a warmer future—usually will be most effective in the months immediately following the event. Yet planning for management intervention in wilderness, along with necessary legal compliance, can take years to accomplish, meaning that the opportunity to effectively intervene after a major disturbance often will be lost. While most wilderness stewards already carry a full load of planning responsibilities, it seems wise to seek opportunities—perhaps beginning as case studies in a few wilderness areas—to complete plans that anticipate sudden, broad-scale disturbances before those disturbances occur, so that responses are more likely to be well planned, timely, and deliberate.

Hedge your bets. Another corollary of our inability to precisely predict the future is that it may be best to plan a variety of different management interventions. For example, in many regions the magnitude and direction of future changes in precipitation are unknown. If the decision is made to restore a landscape denuded by wildfire by planting species adapted to a warmer future, some areas could be planted with species adapted to a warmer, wetter future, some to a warmer, drier future, and some with a mix of both. Each treatment could be repeated in widely dispersed locations, reducing vulnerability by creating redundancy. Similarly, implementing a mixture of restraint, resilience, resistance, and realignment strategies is a means of hedging bets.

Broaden the geographic scope of planning. More than any other threat, climatic change highlights the importance of planning across administrative boundaries. While challenging in itself, regional planning can make certain decisions and actions easier. For example, if climatic changes are driving a species to extinction within a particular wilderness, an initial reaction may be to take expensive, heroic actions to slow the species' decline. But viewed in a regional context, the species might simply be migrating into wildlands farther north. Regional planning could forge agreements ahead of time to allow or facilitate migrations across administrative boundaries as a means of maintaining native biodiversity.

Conclusion

The era of rapid climatic changes is here, and seems sure to bring the greatest challenge wilderness stewards have yet faced. Efforts to plan for and respond to the challenge are still in their infancy, and solutions are unlikely to come easily or quickly. In addition to the considerations we have presented, planning will require a broader engagement of wilderness stewards, policymakers, and the public to assess the implications of climatic changes for wilderness values and policy, a topic well beyond the scope of this article. We hope, however, that we have presented some ideas to help move the process forward; the time for engagement is now.

Acknowledgments

We thank Gregg Fauth, Dave Graber, Peter Landres, and Charisse Sydoriak for valuable comments that greatly improved this article. This work is a contribution from the Western Mountain Initiative, a USGS global change research project.

Literature cited

Aplet, G. H., and D. N. Cole. 2010. The trouble with naturalness: Rethinking park and wilderness goals. Pages 12–29 *in* D. N. Cole and L. Yung, editors. Beyond naturalness: Rethinking park and wilderness stewardship in an era of rapid change. Island Press, Washington, D.C., USA.

Cole, D. N., L. Yung, E. S. Zavaleta, G. H. Aplet, F. S. Chapin III, D. M. Graber, E. S. Higgs, R. J. Hobbs, P. B. Landres, C. I. Millar, D. J. Parsons, J. M. Randall, N. L. Stephenson, K. A. Tonnessen, P. S. White, and S. Woodley. 2008. Naturalness and beyond: Protected area stewardship in an era of global environmental change. George Wright Forum 25(1):36–56.

Gonzalez, P. 2011. Climate change impacts and carbon in U.S. national parks. Park Science 28(1):10–15.

Intergovernmental Panel on Climate Change (IPCC). 2007. Climate change 2007: Synthesis report. Contribution of Working Groups I, II, and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [core writing team R. K. Pachauri and A. Reisinger, editors]. Cambridge University Press, Cambridge, UK, and New York, New York, USA. Available at http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf.

Jansen, E., J. Overpeck, K. R. Briffa, J.-C. Duplessy, F. Joos, V. Masson-Delmotte, D. Olago, B. Otto-Bliesner, W. R. Peltier, S. Rahmstorf, R. Ramesh, D. Raynaud, D. Rind, O. Solomina, R. Villalba, and D. Zhang. 2007. Palaeoclimate. Chapter 6 *in* Climate change 2007: The physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.

S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K. B. Averyt, M. Tignor, and H. L. Miller, editors. Cambridge University Press, Cambridge, UK, and New York, New York, USA.

Landres, P. 2010. Let it be: A hands-off approach to preserving wildness in protected areas. Pages 88–105 *in* D. N. Cole and L. Yung, editors. Beyond naturalness: Rethinking park and wilderness stewardship in an era of rapid change. Island Press, Washington, D.C., USA.

Landres, P., C. Barnes, J. G. Dennis, T. Devine, P. Geissler, C. S. McCasland, L. Merigliano, J. Seastrand, and R. Swain. 2008. Keeping it wild: An interagency strategy to monitor trends in wilderness character across the National Wilderness Preservation System. USDA Forest Service General Technical Report RMRS-GTR-212, Fort Collins, Colorado, USA.

Millar, C. I., N. L. Stephenson, and S. L. Stephens. 2007. Climate change and forests of the future: Managing in the face of uncertainty. Ecological Applications 17:2145–2151.

Nydick, K., and C. Sydoriak. 2011. Alternative futures for fire management under a changing climate. Park Science 28(1):44–47.

Saxon, E., B. Baker, W. W. Hargrove, F. M. Hoffman, and C. Zganjar. 2005. Mapping environments at risk under different global climate change scenarios. Ecology Letters 8:53–60.

Scheffer, M., and S. R. Carpenter. 2003. Catastrophic regime shifts in ecosystems: Linking theory to observation. Trends in Ecology and Evolution 18:648–656.

Scott, D. W. 2002. "Untrammeled," "wilderness character," and the challenges of wilderness preservation. Wild Earth 11(3/4):72–79.

Stephenson, N. L., C. I. Millar, and D. N. Cole. 2010. Shifting environmental foundations: The unprecedented and unpredictable future. Pages 50–66 *in* D. N. Cole and L. Yung, editors. Beyond naturalness: Rethinking park and wilderness stewardship in an era of rapid change. Island Press, Washington, D.C., USA.

Sydoriak, C. A., C. D. Allen, and B. Jacobs. 2000. Would ecological landscape restoration make the Bandelier Wilderness more or less of a wilderness? Wild Earth 10(4):83–90.

Weeks, D., P. Malone, and L. Welling. 2011. Climate change scenario planning: A tool for managing parks into uncertain futures. Park Science 28(1):26–33.

Zahniser, H. 1963. Editorial: Guardians not gardeners. The Living Wilderness 83(spring to summer):2.

About the authors

Nathan L. Stephenson *is a research ecologist with the U.S. Geological Survey, Western Ecological Research Center, Sequoia and Kings Canyon Field Station, Three Rivers, California. He can be reached at nstephenson@usgs.gov.* ***Constance I. Millar*** *is a research paleoecologist with the USDA Forest Service, Sierra Nevada Research Center, Pacific Southwest Research Station, Albany, California. She can be reached at cmillar@fs.fed.us.*

PS

>> COWLEY ET AL. CONTINUED FROM PAGE 33

Literature cited

1964 Wilderness Act (Public Law 88-577).

1966 National Historic Preservation Act (Public Law 89-665), as amended.

1976 Wilderness Designation Act (Public Law 94-567).

1994 California Desert Protection Act (Public Law 103-433).

Cronon, W. 2008. The riddle of the Apostle Islands: How do you manage a wilderness full of human stories? Pages 632–644 *in* M. P. Nelson and J. Baird Callicott, editors. The wilderness debate rages on. University of Georgia Press, Athens, Georgia, USA.

Foster, D., F. Swanson, J. Aber, I. Burke, N. Brokaw, D. Tilman, and A. Knapp. 2003. The importance of land-use legacies to ecology and conservation. BioScience 53:77–88.

Landres, P., C. Barns, J. G. Dennis, T. Devine, P. Geissler, C. S. McCasland, L. Merigliano, J. Seastrand, and R. Swain. 2008. Keeping it wild: An interagency strategy to monitor trends in wilderness character across the National Wilderness Preservation System. General Technical Report RMRS-GTR-212. USDA Forest Service, Rocky Mountain Research Station, Fort Collins, Colorado, USA.

National Wilderness Steering Committee. 2002. Cultural resources and wilderness. Guidance "White Paper" Number 1. 30 November. National Wilderness Steering Committee, USDI National Park Service, Washington D.C., USA.

Olympic Park Associates v. Mainella. 2005. *Olympic Park Associates, Wilderness Watch, and Public Employees for Environmental Responsibility v. Fran P. Mainella, Jonathan Jarvis, and William Laitner*. United States District Court Western District. Case No. C04-5732FDB, filed 1 August 2005.

Sydoriak, C. A., C. D. Allen, and B. F. Jacobs. 2000. Would ecological landscape restoration make the Bandelier Wilderness more or less of a wilderness? Wild Earth 10:83–90.

Wallington, T. J., R. J. Hobbs, and S. A. Moore. 2005. Implications of current ecological thinking for biodiversity conservation: A review of the salient issues. Ecology and Society 10:15.

Zahniser, H. 1956. The need for wilderness areas. The living wilderness 59 (Winter to Spring):37–43.

About the authors

Jill Cowley *is a historical landscape architect with the National Park Service, Intermountain Region, Santa Fe, New Mexico. She can be reached at jill_cowley@nps.gov.* ***Peter Landres*** *is an ecologist with the Aldo Leopold Wilderness Research Institute, Rocky Mountain Research Station, USDA Forest Service, Missoula, Montana.* ***Melissa Memory*** *is chief of Cultural Resources at Everglades and Dry Tortugas National Parks, Homestead, Florida.* ***Doug Scott*** *is manager of Policy and Research, Campaign for America's Wilderness, The Pew Charitable Trusts.* ***Adrienne Lindholm*** *is the NPS Alaska Region Wilderness Coordinator, Anchorage, Alaska.*

PS

COMMENTARY

Climate change threatens wilderness integrity*

By David Graber

History and culture

The Wilderness Act of 1964 was written in a time when nature was thought to be static, or at least changing at the pace of millennia. In the act, wilderness is "recognized as an area where the earth and its community of life are untrammeled by man … retaining its primeval character and influence … and managed so as to preserve its natural conditions and which … generally appears to have been affected primarily by the forces of nature" (Section 2c). By the 1980s, ecologists had come to realize that while ecosystems trend toward homeostasis in the absence of disruptive forces, those forces—fire, flood, drought, disease outbreaks—impinge periodically, if not frequently, on most ecosystems. In living systems, "primeval" just does not happen. Nonetheless, among wilderness managers, recreationists, and activists, nostalgia for a more primitive and stable world runs very powerfully, as it does in the national park movement. As President Lyndon B. Johnson reportedly said upon signing the Wilderness Act in 1964: "If future generations are to remember us with gratitude rather than contempt, we must leave them more than the miracles of technology. We must leave them a glimpse of the world as it was in the beginning, not just after we got through with it."

It is certainly true that when Congress passed the Eastern Wilderness Areas Act in 1975, it tacitly acknowledged that a *legal* wilderness could, in fact, have been subjected in the past to alteration by humans, even industrial humans. The Shenandoah Wilderness once was logged, settled, and farmed intensively. The Phillip Burton Wilderness in Point Reyes National Seashore affords a glimpse of the San Francisco skyline. However, to most people who are accustomed to backpacking or stockpacking, *wilderness* is epitomized by large (western) landscapes. According to Wilderness.net[1] (2011),

*The opinions expressed by the author do not necessarily reflect the policies or positions of the U.S. government.

[1]Wilderness.net is a partnership of the Wilderness Institute at the University of Montana, the Arthur Carhart National Wilderness Training Center, and the Aldo Leopold Wilderness Research Institute.

In living systems, "primeval" just does not happen.

"Wilderness is the land that was—wild land beyond the frontier … land that shaped the growth of our nation and the character of its people."

The Wild Foundation (2011) broadly defines wilderness areas as the "most intact, undisturbed wild natural areas left on our planet—those last truly wild places that humans do not control and have not developed with roads, pipelines or other industrial infrastructure." It goes on to state, "A wilderness area is not necessarily a place that is biologically 'pristine.' Very few places on earth are not in some way impacted by humans. Rather, the key is that a wilderness area be mainly biologically intact: evidence of minor human impacts, or indications of historical human activity does not disqualify an area from being considered wilderness."

According to The Wilderness Society (2011): "Wilderness offers people solitude, inspiration, natural quiet, a place to get away. At the same time, designated wilderness protects biodiversity, the web of life.… Of 261 basic ecosystem types in the U.S., 157 are represented in the wilderness system. Without these large, complex areas of preserved landscape, species protection would be virtually impossible and our understanding of how natural systems work would be reduced to childish speculation."

Change

Climate change is going to produce a wilderness experience quite unlike these descriptions. Landscape integrity, ecosystem integrity, and landscape aesthetics will all suffer visibly. Over the decades to come, glaciers and snowfields will continue their retreat. Some perennial stream systems will become ephemeral, losing fish and other native biota. Fire seasons will lengthen and fires will become more severe. Floods and droughts will intensify and become more frequent. Individual tree and forest stand die-offs—from insects, disease, insufficient water, or excessive heat—will accelerate. Landscapes disrupted in these ways are both unhealthy and unattractive.

As microclimates move—mostly north and upslope—the plants and animals left behind will find circumstances increasingly stressful. Recruitment will decline and mortality will increase. Species that can do so, by nature of their life histories and lack of obstacles, will colonize new areas when and if these places become habitable. Notable among plant and animal species most effective at exploiting newly available habitats are the so-called weedy species. To the ecologically uninformed, some weedy species, such as French broom (*Genista monspessulana* [L.] L. Johnson), can be attractive. But the notable feature of weeds is that because they are cosmopolitan, they destroy the distinctiveness of a place by making it look more like all other places that support those same species. Local (alpha) species diversity may actually increase, but beta diversity—the differences among different places—is lost in the process.

As has been noted in the aftermath of catastrophic lethal events such as volcanic eruptions, the early decades of biological colonization do not "look right." The places where plant species first establish tend to be random—wherever they can get a foothold—and free of the normal competition within a settled biological community that produces distinct distribution patterns on the landscape. For example, one species may best be able to compete on steep slopes, while another favors valley bottoms. Having spent time in a wilderness or other intact landscape, a visitor unconsciously expects this systematic patterning. However, because climate change will be progressive over many decades, this patterning will not have a chance to develop and the landscape will appear chaotic.

Future

Western wildernesses may offer the best opportunities for conserving native biodiversity because they tend to be large intact ecosystems with fewer anthropogenic stressors. However, "the best" may turn out not to be good enough for many na-

When climate change begins to impose substantial hardships on society, … we can expect renewed calls for water storage and diversion projects … [involving] western mountain wildernesses.

tive species. The National Park Service and other wilderness managers may feel the need to provide sanctuary for species that have lost suitable habitat elsewhere, as well as to provide ecosystem resilience and resistance through engineering. Intentional manipulation of forest stand structure, hydrologic manipulation of watersheds, and control of invasive species are examples of ways to improve ecosystem resilience and resistance to climate change; however, they clearly do not leave them either untrammeled or "with the imprint of man's work substantially unnoticeable" (Section 2c).

The headwaters of large, economically important watersheds are frequently found at the top of mountains in wilderness, as in the cases of Rocky Mountain National Park, Olympic, and Yosemite Wildernesses. Increasingly, the need for better understanding of climate at a fine scale, and hydrologic systems in particular, has led to requests for hydro-meteorological (hydromet), snow pillow, streamflow, and soil moisture measuring installations in wilderness. Some of these requests have been approved. This is a direct challenge to the language of the Wilderness Act itself, which prohibits permanent structures, but it reflects the profound importance of water in the dry West. Pressure has been strong from the research community as well as water management agencies to install more water-measuring devices in wilderness, despite their visual intrusion on wilderness character.

When climate change begins to impose substantial hardships on society, as when water storage from mountain snowpack has been substantially lost, we can expect renewed calls for water storage and diversion projects. Some of these inevitably will involve western mountain wildernesses. Similarly, in the desert wildernesses there is a large potential to produce wind, solar, and sometimes geothermal energy. Even if these projects can be precluded from wilderness, it may be more difficult in the future to route transmission lines away from wilderness when their placement in it could save substantial amounts of money.

As climate change disrupts the lives of millions of people, will society still place a high value on wilderness? That remains to be seen.

References

The Wild Foundation. 2011. What is a wilderness area? Accessed 24 May 2011 at http://www.wild.org/main/how-wild-works/policy-research/what-is-a-wilderness-area.

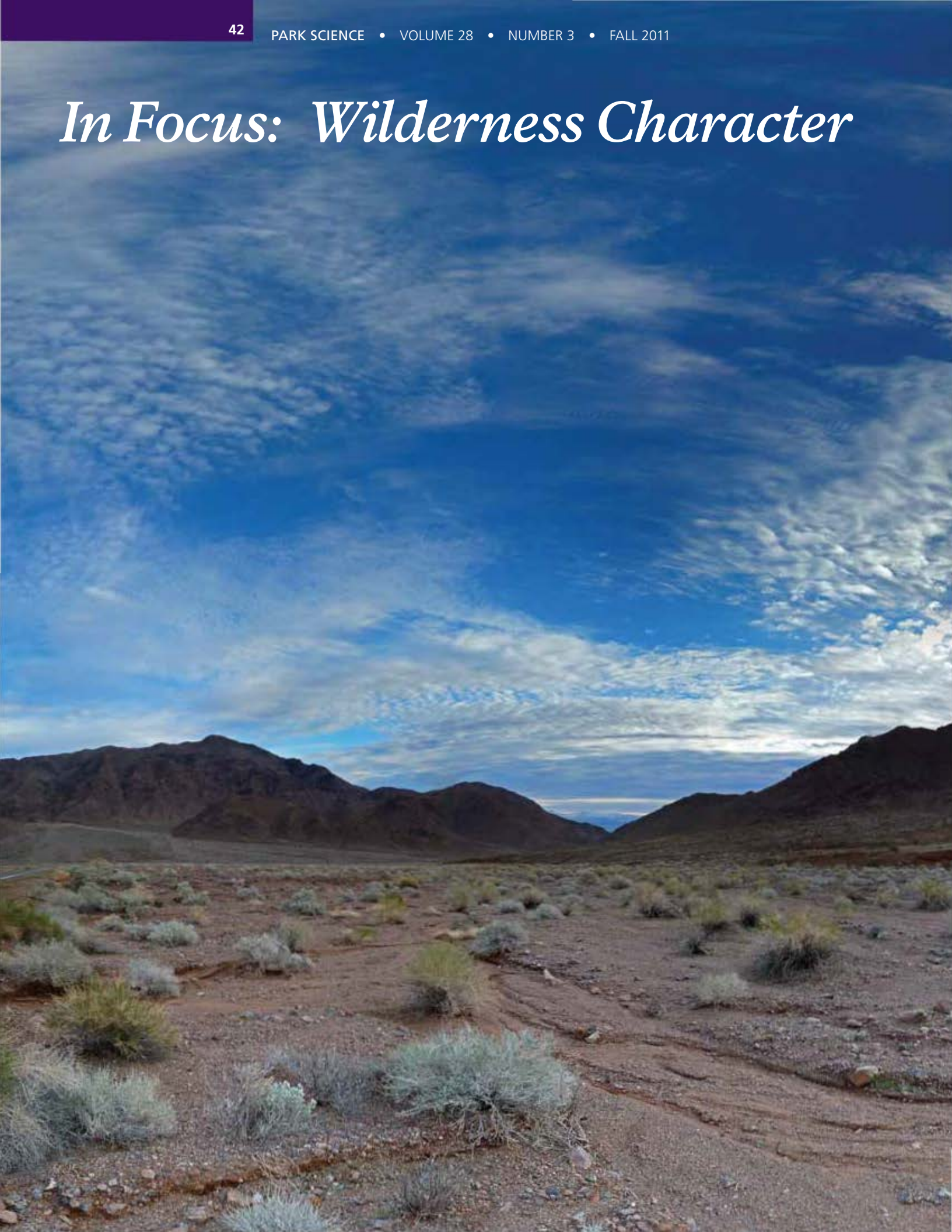
The Wilderness Society. 2011. What is wilderness? Accessed 24 May 2011 at http://wilderness.org/content/what-wilderness.

Wilderness.net. 2011. What is wilderness? Accessed 24 May 2011 at http://www.wilderness.net/index.cfm?fuse=NWPS&sec=whatIsWilderness.

About the author

David Graber *is chief scientist for the NPS Pacific West Region. He is stationed at Sequoia and Kings Canyon National Parks in California. Graber has more than 30 years' experience working as an ecologist for the National Park Service and the U.S. Geological Survey in the Sierra Nevada, primarily in wilderness, and has consulted for parks throughout the Pacific West Region. He served on the (former) NPS Wilderness Steering Committee and was principal author of its white paper on ecological restoration in wilderness. His research interests have been overridden by the impacts of climate change on native ecosystems in parks and protected areas. He can be reached at david_graber@nps.gov.*

In Focus: Wilderness Character



The qualities of wilderness character are evident in this desert landscape and clouds lit by the setting sun in southern Death Valley Wilderness. This detailed photograph by Peter Landres—a composite of 39 individual images stitched together—tied for third place in the recent *Park Science* wilderness photo content.

NPS/PETER LANDRES

STATE OF SCIENCE

Using wilderness character to improve wilderness stewardship

By Peter Landres, Wade M. Vagias, and Suzy Stutzman

Abstract
This article describes how understanding wilderness character leads to improved communication among staff and with the public, helping park staff make more informed decisions about park planning, management, and monitoring in wilderness. Wilderness character is defined in terms of five qualities: natural, solitude or primitive and unconfined recreation, undeveloped, untrammeled, and other features. These qualities can be used to improve wilderness stewardship and foster consistent stewardship across the National Wilderness Preservation System (NWPS).

Key words
management, monitoring, planning, wilderness character, wilderness stewardship

THE 1964 WILDERNESS ACT (PUBLIC LAW 88-577) ESTAB-lished the National Wilderness Preservation System (NWPS) "for the protection of these areas, the preservation of their wilderness character" (Section 2a). In congressional testimony clarifying the intent of wilderness designation, Zahniser (1962) said, "The purpose of the Wilderness Act is to preserve the wilderness character of the areas to be included in the wilderness system, not to establish any particular use." Congress (United States Congress 1983) and legal scholars (Rohlf and Honnold 1988; McCloskey 1999) subsequently confirmed that preserving wilderness character is the act's primary legal mandate. Further, the policies of all four agencies that manage wilderness state that they are to preserve wilderness character in all areas designated as wilderness.

Despite a clear legal mandate and agency policies, in the 47 years since passage of the 1964 Wilderness Act, there has been no legal definition of wilderness character (Scott 2002) and no National Park Service guidelines or direction to assess how management affects wilderness character or to measure its loss or preservation. Compounding this lack of definition and management guidelines, the complexity of wilderness and the values and meanings associated with it have at times led to a lack of understanding about wilderness and its stewardship, miscommunication among agency staff, and miscommunication between agencies and the public.

Defining wilderness character

Based on Section 2c, "Definition of Wilderness," in the 1964 Wilderness Act and building on the writing of Howard Zahniser (Zahniser 1956; Harvey 2007), wilderness scholars (Rohlf and Honnold 1988; McCloskey 1999; Scott 2002), and earlier work to describe and use wilderness character (Landres et al. 2005; Landres et al. 2008b), an interagency team published *Keeping It Wild* (Landres et al. 2008a), which identified four distinct and necessary "qualities" of wilderness character. These qualities were selected to be tangible, link local conditions and management directly to the statutory language of the 1964 Wilderness Act, and apply throughout the entire area of a wilderness. They apply to every wilderness regardless of size, location, agency administration, or any other attribute.

1. Natural. Wilderness ecological systems are substantially free from the effects of modern civilization. This quality is degraded by many things, such as loss of indigenous species, occurrence of nonindigenous species, alteration of ecological processes such as waterflow and fire regimes, effects of climate change, loss of dark skies, and occurrence of artificial sounds. It is preserved or improved, for example, by controlling or removing nonindigenous species or restoring ecological processes.

2. Solitude or a primitive and unconfined type of recreation. Wilderness provides outstanding opportunities for solitude or primitive and unconfined recreation. This quality is primarily about the opportunity for people to experience wilderness, and is influenced by settings that affect this opportunity. It is preserved or improved by management actions that reduce visitor encounters and signs of modern civilization inside the wilderness. In contrast, this quality is degraded by agency-provided recreation facilities, management restrictions on visitor behavior, and actions that increase visitor encounters.

3. Undeveloped. Wilderness retains its primeval character and influence and is essentially without permanent improvement or modern human occupation. This quality is influenced by what are commonly called the "Section 4c prohibited uses," that is, the presence of modern structures, installations, habitations, and use of motor vehicles, motorized equipment, or mechanical transport. The removal of structures and not conducting these

Despite a clear legal mandate and agency policies, in the 47 years since passage of the 1964 Wilderness Act, there has been no legal definition of wilderness character … and no National Park Service guidelines or direction to assess how management affects wilderness character or to measure its loss or preservation.

prohibited uses preserve or improve this quality. In contrast, the presence of structures and prohibited uses degrades this quality, whether by the agency for administrative purposes, by others authorized by the agency, or when there are unauthorized uses.

4. Untrammeled. Wilderness is essentially unhindered and free from the actions of modern human control or manipulation. This quality is influenced by any activity or action that controls or manipulates the components or processes of ecological systems inside the wilderness. Management actions that are not taken support or preserve the untrammeled quality, while actions that are taken degrade this quality, even when these actions are taken to protect resources, such as spraying herbicides to eradicate or control nonindigenous species or reducing fuels accumulated from decades of fire exclusion.

In addition to these four qualities, there may be a fifth quality, called *other features*, based on the last clause of Section 2c in the 1964 Wilderness Act, that a wilderness "may also contain ecological, geological, or other features of scientific, educational, scenic, or historical value." Unlike the preceding four qualities that apply to every wilderness, this fifth quality is unique to an individual wilderness based on the features that are inside that wilderness. These features typically occur only in specific locations within a wilderness and include cultural resources, historical sites, paleontological sites, or any feature not in one of the other four qualities that has scientific, educational, scenic, or historical value. While many different types of features could be included, the intent is to include those that are significant or integral to the park and wilderness. Features mentioned in park or wilderness enabling legislation would likely qualify, such as the historic sites in Death Valley Wilderness and volcanoes in Katmai Wilderness. Likewise, significant cultural sites, whether mentioned in enabling legislation or not, occur in most wildernesses and have scientific, educational, scenic, or historical value.

These five qualities interact in direct and subtle ways, ways that may complement or conflict with each other. For example, allowing a natural fire ignition to burn preserves both the natural and untrammeled qualities of a wilderness. In contrast, suppressing a natural ignition degrades the untrammeled quality, the use of helicopters or other motorized firefighting equipment degrades the undeveloped and solitude qualities, and the long-term effect of suppression may degrade the natural quality. Sometimes a decision to protect one quality of wilderness character may directly degrade another quality. Designated campsites, for instance, may be necessary to protect solitude or prevent vegetation trampling but degrade the unconfined quality of wilderness character by requiring visitors to camp only in designated sites. In all cases, using wilderness character does not drive a particular decision or management action—it is a tool to help staff be comprehensive, systematic, and consistent in evaluating potential benefits and impacts to make an informed and transparent decision.

Wilderness issues are often value-laden and public discussions can quickly bog down on words and ideas that have different meanings for different people. Wilderness character offers a tangible, consistent, and positive vision for wilderness and its stewardship, in turn fostering better discussion with the public.

Like a violin composed of separate pieces that interact to form something greater than the sum of its parts, these five qualities together form a complex set of relationships among the land, its stewardship, its users, and the values and benefits that society derives from wilderness. These five qualities form the physical and stewardship setting of a wilderness. This setting in turn provides tangible scientific, cultural, educational, and economic values to society that are not directly part of wilderness character, but are derived from it (Cordell et al. 2005). For example, the scientific value of wilderness as a reference baseline to assess and understand the effects of climate change results from this setting. Similarly, spiritual (Ashley 2007; Moore 2007), ethical (Cafaro 2001), and other intangible values and benefits to society derive from this wilderness setting.

Using wilderness character improves communication and decision making

Defining wilderness character provides a standard nomenclature to help staff understand wilderness and assess stewardship trade-offs. At the national level, wilderness character provides a framework for consistent stewardship across all wildernesses. At the local level, understanding these qualities improves internal and external communication, and helps staff make more informed decisions.

Better communication. Understanding wilderness character improves internal and external communication. Internally, staff would understand how wilderness is the responsibility of all divisions and programs within a park and how their work directly contributes to wilderness stewardship. For example, a wildlife biologist would understand how data on small-mammal populations directly contribute to tracking change in the natural quality of wilderness character. Trail crews would understand how motorized equipment and mechanical transport degrade the undeveloped quality of wilderness character and why these are generally prohibited even though they may be convenient. Externally, standardized nomenclature provides a clearer basis for discussions with the public about wilderness and its stewardship. Wilderness issues are often value-laden and public discussions can quickly bog down on words and ideas that have different meanings for different people. Wilderness character offers a tangible, consistent, and positive vision for wilderness and its stewardship, in turn fostering better discussion with the public. Using wilderness character can also help interpretation and education staff design programs to help the public understand the values and meanings of wilderness and its stewardship.

Better decisions. Understanding wilderness character can help all staff see how various management pieces fit together to affect wilderness, and how individual decisions and actions work toward degrading or preserving it. Discussing how proposed actions affect the five qualities is an easy way to improve transparency and accountability, and help staff evaluate the impacts of potential decisions more quickly and systematically. For example, a proposal to install a toilet in a heavily used area to reduce resource damage can be evaluated in terms of the positive and adverse effects of the toilet on the natural, undeveloped, and solitude or primitive and unconfined qualities.

Using wilderness character improves planning, management, and monitoring

Wilderness character can be integrated into existing procedures to develop management plans, evaluate project impacts and management decisions, and develop monitoring direction.

Planning

Wilderness character can be integrated into most aspects of the planning process, resulting in proactive wilderness stewardship. Wilderness character can drive the process of developing general management plans (GMPs), GMP amendments, park founda-

tions, and wilderness stewardship plans. It can also be incorporated into other types of plans, such as fire management plans, invasive or exotic species plans, resource stewardship strategies, and long-range interpretive plans.

Preserving or enhancing wilderness character should be the purpose of wilderness stewardship plans, with specific goals and objectives stemming from the five wilderness qualities. Issues, challenges, and opportunities can all be framed and discussed within the context of wilderness character, allowing a dialogue and common understanding of the choices made during public involvement and agency and tribal consultation. A central part of planning is developing alternatives, and the concepts that define and differentiate alternatives can be driven by wilderness character. For example, one alternative may emphasize preserving the untrammeled quality and limit actions that might otherwise be taken for ecological restoration. Another alternative may emphasize improving the natural quality by allowing ecological restoration actions that in the short term would degrade the untrammeled quality. Zones may be established within a wilderness, and wilderness character can drive desired conditions and management actions, resulting in different effects on wilderness character in different zones.

Most plans have a common framework to establish desired conditions, measures, standards, and a range of management actions if the standards are exceeded. Commonly used frameworks such as user (carrying) capacity in GMPs, Visitor Experience and Resource Protection, and the Limits of Acceptable Change processes are largely structured around visitor experience and visitor impacts on resources. Integrating the concept of wilderness character into a planning framework embraces more of the complexity and wholeness of wilderness. Environmental compliance documents that affect wilderness resources can focus on the qualities of wilderness character in the description of the affected environment and analysis of impacts, resulting in a clear understanding of the different outcomes by managers and the public.

Management

Cumulative impacts of management decisions are a growing concern among wilderness managers. The holistic framework of wilderness character can help minimize this "tyranny of small decisions" (Odum 1982) by clarifying the breadth of agency responsibilities in managing wilderness, and by helping staff understand their role and responsibility to preserve all five qualities of wilderness character. Wilderness character can be incorporated into training and operational procedures of all divisions, encouraging an ethic that promotes the preservation of wilderness character in search and rescue, maintenance of structures in wilderness, visitor contacts, ranger activities, safety, interpretation, education, and other park programs and activities.

A Minimum Requirements Analysis (MRA) is required by NPS policy for all actions in wilderness. Effects on wilderness character are a formal part of the MRA process for determining whether the action is necessary, and if it is, for then identifying the minimum activity. Similarly, wilderness character is used as the basis to evaluate impacts from proposed science activities in wilderness (Landres et al. 2010). Science is one of the stated legal values of wilderness and is essential for helping managers make informed decisions, but it may also have adverse impacts on wilderness character. For example, a proposal to trap and collar endangered wildlife may not require motor vehicles or mechanical transport, but the process of trapping would degrade the untrammeled quality and installing radio collars would degrade the undeveloped quality. Using wilderness character to understand these impacts allows up-front and explicit communication between scientists and managers, increasing the likelihood that high-quality science proposals that provide crucial benefits will be approved and wilderness character will be preserved.

Monitoring

Tracking change in wilderness character over time provides answers to crucial on-the-ground questions such as how management decisions and actions, and external activities affect wilderness character. Such questions can be answered using the interagency monitoring strategy in *Keeping It Wild*, which provides a way to track change in wilderness character on the ground in each wilderness while maintaining national consistency. The basic elements of this strategy are as follows.

Keep it useful. Use measures that are identified by local staff as relevant to that particular wilderness.

Keep it practical. Use existing data whenever and wherever possible.

Keep it simple. Use the smallest number of measures to track change in the five qualities over time.

By tracking change in locally relevant measures of wilderness character, each wilderness will have the information about trends to help staff understand the consequences or outcomes of their decisions and actions. For example, if the use of designated campsites is initiated in a particular area to reduce vegetation impacts, the trend in the natural quality should improve while the trend in the unconfined quality will degrade.

Using the procedures from *Keeping It Wild*, the trend of each measure—improving, stable, or degrading—is combined to yield overall trends in each quality and of wilderness character. These trends can be compiled across wildernesses to assess whether wilderness character is being preserved across a region or the nation. This strategy allows each wilderness to use unique measures yet still contribute to an NPS-wide and NWPS-wide assessment of trends in wilderness character (see Adams et al., pages 58–59).

Conclusions

The National Park Service is in a unique position to demonstrate leadership in wilderness stewardship by preserving wilderness character now and into the future. Integrating wilderness character into planning, management, and monitoring helps enhance communication, accountability, and consistency of wilderness stewardship in the National Park Service and across the National Wilderness Preservation System. Understanding and preserving wilderness character sustains the values and benefits of wilderness for future generations. More information about wilderness character is available on the wilderness.net Web site and the Wilderness Character Integration Hub (SharePoint site) at http://share.nps.gov/wci.

Acknowledgments

We thank Adrienne Lindholm, Chris Barns, Michele Jesperson, and the anonymous reviewers for their comments on a previous draft of this article. We also thank the many dedicated individuals from the Bureau of Land Management, U.S. Fish and Wildlife Service, National Park Service, and USDA Forest Service for their key contributions in developing the concept of wilderness character and for their continued passion for preserving wilderness character.

Literature cited

Ashley, P. 2007. Toward an understanding and definition of wilderness spirituality. Australian Geographer 38(1):53–69.

Cafaro, P. 2001. Thoreau, Leopold, and Carson: Toward an environmental virtue ethics. Environmental Ethics 22:3–17.

Cordell, K. H., J. C. Bergstrom, and J. M. Bowker. 2005. The multiple values of wilderness. Venture Publishing, State College, Pennsylvania, USA.

Harvey, M. 2007. Wilderness forever: Howard Zahniser and the path to the Wilderness Act. University of Washington Press, Seattle, Washington, USA.

Landres, P., S. Boutcher, L. Merigliano, C. Barns, D. Davis, T. Hall, S. Henry, B. Hunter, P. Janiga, M. Laker, A. McPherson, D. S. Powell, M. Rowan, and S. Sater. 2005. Monitoring selected conditions related to wilderness character: A national framework. General Technical Report RMRS-GTR-151. USDA Forest Service, Rocky Mountain Research Station, Fort Collins, Colorado, USA.

Landres, P., C. Barns, J. G. Dennis, T. Devine, P. Geissler, C. S. McCasland, L. Merigliano, J. Seastrand, and R. Swain. 2008a. Keeping It Wild: An interagency strategy to monitor trends in wilderness character across the National Wilderness Preservation System. General Technical Report RMRS-GTR-212. USDA Forest Service, Rocky Mountain Research Station, Fort Collins, Colorado, USA.

Landres, P., M. B. Hennessy, K. Schlenker, D. N. Cole, and S. Boutcher. 2008b. Applying the concept of wilderness character to national forest planning, monitoring, and management. General Technical Report RMRS-GTR-217WWW. USDA Forest Service, Rocky Mountain Research Station, Fort Collins, Colorado, USA.

Landres, P., M. Fincher, L. Sharman, J. Alderson, C. Barns, T. Carlson, R. L. Anderson, S. Boudreau, D. J. Parsons, L. Boyers, and K. Hood. 2010. An interagency framework to evaluate proposals for scientific activities in wilderness. General Technical Report RMRS-GTR-234WWW. USDA Forest Service, Rocky Mountain Research Station, Fort Collins, Colorado, USA.

McCloskey, M. 1999. Changing views of what the wilderness system is all about. Denver University Law Review 76:369–381.

Moore, K. D. 2007. In the shadow of the cedars: The spiritual value of old-growth forests. Conservation Biology 21:1120–1123.

Odum, W. E. 1982. Environmental degradation and the tyranny of small decisions. Bioscience 32:728–729.

Rohlf, D., and D. L. Honnold. 1988. Managing the balance of nature: The legal framework of wilderness management. Ecology Law Quarterly 15:249–279.

Scott, D. W. 2002. "Untrammeled," "wilderness character," and the challenges of wilderness preservation. Wild Earth 11(3/4):72–79.

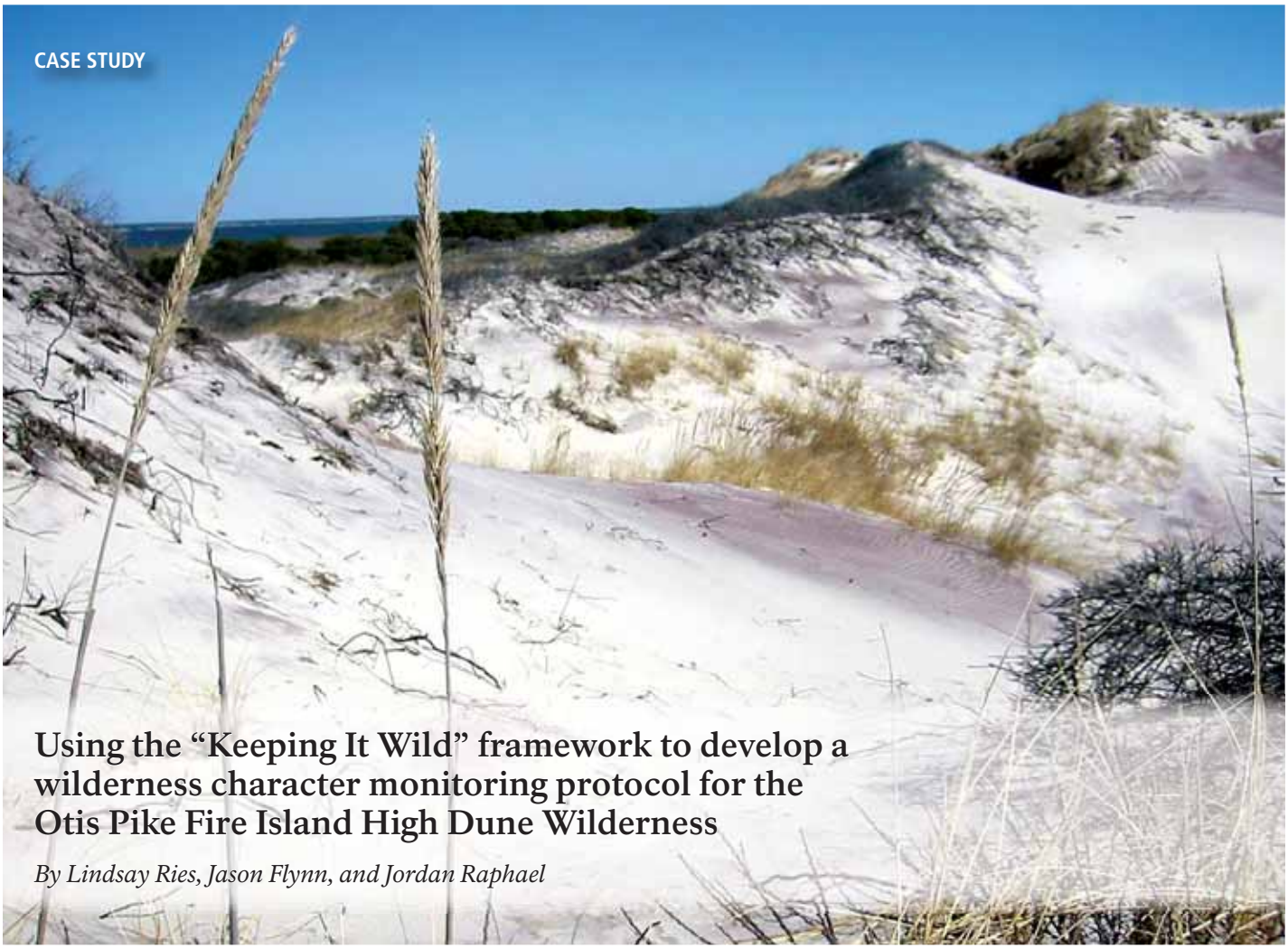
United States Congress. 1983. U.S. House Report 98-40 from the Committee on Interior and Insular Affairs, 18 March, p. 43.

Zahniser, H. 1956. The need for wilderness areas. The Living Wilderness 59 (Winter to Spring):37–43.

_____. 1962. Hearings before the Subcommittee on Public Lands of the Committee on Interior Affairs, House of Representatives, 87th Congress, 2nd session, 7–11 May, serial no. 12, part IV.

About the authors

Peter Landres *(plandres@fs.fed.us) is an ecologist at the Aldo Leopold Wilderness Research Institute, Rocky Mountain Research Station, USDA Forest Service, Missoula, Montana.* ***Wade M. Vagias*** *is a management assistant with Yellowstone National Park, Wyoming.* ***Suzy Stutzman*** *is wilderness coordinator in the Intermountain Region, National Park Service, Denver, Colorado.*



NPS/JASON FLYNN

Using the "Keeping It Wild" framework to develop a wilderness character monitoring protocol for the Otis Pike Fire Island High Dune Wilderness

By Lindsay Ries, Jason Flynn, and Jordan Raphael

Figure 1. The Otis Pike Fire Island High Dune Wilderness is the only federally designated wilderness in New York State and, at 1,380 acres (559 ha), is the smallest wilderness area managed by the National Park Service. The wilderness contains a variety of dynamic barrier island habitats in relatively natural condition within 60 miles of New York City. The northern boundary extends along the Great South Bay at mean high water and is characterized by an extensive salt marsh. The southern boundary is legislatively defined as "the toe of the primary dune," and is ever changing because of the dynamic nature of the beach-dune system.

THE OTIS PIKE FIRE ISLAND HIGH DUNE WILDERNESS WAS established by the Congress within the boundaries of Fire Island National Seashore, New York, in 1980 (fig. 1). Early park management documents cited the Wilderness Act of 1964 and the need to "preserve wilderness character"; however, more than 30 years later, park staff still lacks an effective means to evaluate how well wilderness character is being preserved. Fire Island National Seashore needed a way to monitor and evaluate the effects of visitation, ecological change, and management actions on this small, urban, proximate, dynamic barrier island wilderness.

An interdisciplinary team at the national seashore used the "Keeping It Wild" conceptual framework to develop indicators and measures to produce a wilderness character monitoring protocol (Landres et al. 2008a). All wilderness areas, regardless of size, location, or any other feature, are unified by the statutory definition of wilderness, and each quality has relevant indicators and quantitative measures that can be used to evaluate wilderness character trends (Wilderness Act). The framework allows flexibility for each agency and individual wilderness areas to monitor the specific measures most representative of their site.

Choosing indicators and measures

The team consisted of two park biologists and one visitor and resource protection ranger, all of whom have individually monitored particular conditions in the Otis Pike Fire Island High Dune Wilderness. The plan was to establish baselines and use existing relevant monitoring activities to develop a holistic

approach to monitoring wilderness character at our site. The team began by reviewing the example indicators for each quality in the interagency monitoring framework (Landres et al. 2008b) and eliminating indicators that were not applicable to the site. For each quality we then considered the remaining indicators and discussed possible measures. These discussions led the team to create new indicators and measures not mentioned in the Landres et al. report (2008b) that fit within the park's own unique wilderness character.

Choosing indicators and representative measures was the most challenging part of the process. The team summarized existing data sources and quantitative measures already used in the wilderness through routine monitoring and management actions. We then discussed whether we could use these metrics for particular qualities within our framework. There were many data sources for our site, with most of our data available from different divisions at Fire Island National Seashore as well as the NPS Inventory and Monitoring Northeast Coastal and Barrier Network (NCBN). Within the boundaries of the wilderness area, park staff monitors and manages for threatened and endangered species, vegetation (native and nonnative invasive species), mosquito-borne diseases, white-tailed deer (density surveys), backcountry camping, visitation (visitor use reports), legislatively authorized waterfowl hunting, adjacent off-road vehicle use, and law enforcement incidents (fig. 2). In addition, ecologists with the Northeast Coastal and Barrier Network have identified several vital signs for long-term monitoring (NCBN 2011). For example, the network implemented monitoring in the wilderness area to evaluate changes in salt-marsh vegetation community structure and it will be continued in the future.

After summarizing all existing monitoring measures in Otis Pike Fire Island High Dune Wilderness, we had to decide which ones were relevant to and representative of the character of our wilderness and which should be included in the protocol. We decided to include those that were part of the park's base programs or long-term monitoring plan rather than other short-term and research efforts.

After identifying existing and relevant measures, we went through each quality and identified data gaps or areas for which a measure should be created. For example, a night sky monitoring program (to measure light pollution) was developed for our site. Park management agreed with the team that experiencing night sky during primitive backcountry camping is an important part of visitors' wilderness experience. We included as many relevant indicators and subsequent measures as possible to fully represent each quality (table 1, page 52).

Abstract
This article discusses wilderness character protocol development for the Otis Pike Fire Island High Dune Wilderness, located within 60 miles of New York City and the smallest wilderness unit administered by the National Park Service. We used the "Keeping It Wild" framework (Landres et al. 2008a), which is based on the four qualities of wilderness character: untrammeled, natural, undeveloped, and solitude or primitive and unconfined recreation. Several indicators and subsequent quantitative measures were chosen for each quality based on the needs and conditions of this particular wilderness area using existing monitoring programs and databases as much as possible. The process of developing a wilderness character monitoring protocol helped staff view wilderness holistically and reflect on best management practices for preserving wilderness character as mandated in the 1964 Wilderness Act. This case study provides other wilderness areas administered by the National Park Service (NPS) with an example of how one team interpreted wilderness character for their site and, ultimately, expanded their understanding of wilderness stewardship.

Key words
Fire Island National Seashore, monitoring, Otis Pike Fire Island High Dune Wilderness, wilderness, wilderness character

Evaluating trends

Once the measures were identified, the team established a method to rank, summarize, and assess trends in wilderness character. Landres et al. (2009) discuss how to synthesize data, and we used this information in developing our wilderness character trend worksheet. For example, the decrease in acreage of invasive plant species, a measure of the "plant and animal species and communities" indicator under the natural quality, would cause an increase in wilderness character (table 2, page 53). The first year of monitoring acts as a baseline for wilderness character so subsequent measures are compared with the previous year. In this way we can assess whether wilderness character is improving (+1 or ↑), degrading (–1 or ↓), or stable (0 or ↕) overall and, for each measure, indicator and quality (table 2). Trends can be discerned by simply adding the rankings. All our measures are equally weighted, allowing for an evaluation of change but not for the magnitude of that change. Once the protocol is established we can start looking at long-term trend analyses of wilderness character on a temporal basis.

Evaluating trends allows wilderness managers to see the impacts of management decisions, visitation, and ecological change on wilderness character. Managers can evaluate trends on a small or large scale, from an individual measure within one of the qualities to overall wilderness character across all four qualities. Identifying which measures show a "degrading" or –1 trend will highlight areas in which management decisions may need to be altered.

Figure 2. Park staff annually monitors threatened and endangered species, such as piping plovers (above left) and seabeach amaranth (above center). Nonnative invasive species such as Japanese black pine (above right) are also monitored and controlled. Data from ongoing natural resource management monitoring programs (map) will be used for the indicator, "plant and animal species and communities," within the natural quality of wilderness character.

The protocol is a tool and should remain flexible so that it can be amended as changes occur to more accurately represent wilderness character of the site in the future.

Interestingly, management activities can have a degrading effect on wilderness character in the short term but have a positive long-term effect. For example, the action of removing nonnative inva-

Table 1. Final wilderness character monitoring framework developed for the Otis Pike Fire Island High Dune Wilderness

Quality	Indicator	Measures	Trend
Untrammeled Wilderness is essentially unhindered and free from modern human control or manipulation	Actions authorized by Fire Island National Seashore that manipulate the biophysical environment	Number of actions to manage plants, animals, pathogens, soil, water or fire	↑ in number of actions = ↓ in wilderness character
		Number of natural fire starts that receive a suppression response	↑ in number of actions = ↓ in wilderness character
	Actions not authorized by the NPS-FIIS that manipulate the biophysical environment	Number of unauthorized actions by other federal or state agencies, citizen groups, or individuals that manipulate plants, animals, pathogens, soil, water, or fire	↑ in number of actions = ↓ in wilderness character
Natural Wilderness ecological systems are substantially free from the effect of modern civilization	Plant and animal species and communities	Number of native species that are listed as threatened and endangered, sensitive, or of concern	↑ in number = ↑ in wilderness character
		Abundance of native species that are listed as threatened and endangered, sensitive, or of concern	↑ in abundance = ↑ in wilderness character
		Number of nonnative invasive species	↑ in number = ↓ in wilderness character
		Acreage of nonnative invasive species	↑ in acreage = ↓ in wilderness character
	Physical resources	Ozone air pollution based on concentrations of N100 episodic and W126 chronic ozone exposure affecting sensitive plants	↑ in ozone = ↓ in wilderness character
		Extent and magnitude of change in water quality	↑ in wilderness quality measurements = ↓ in wilderness character
	Biophysical resources	Forest health	↑ in acreage = ↓ in wilderness character
		Salt-marsh elevation	↑ in elevation = ↑ in wilderness character
Undeveloped Wilderness is essentially without permanent improvements or modern human occupation	Nonrecreational structures, installations, and developments	Number of authorized physical developments	↑ in number = ↓ in wilderness character
		Number of unauthorized (user-created) physical developments	↑ in number = ↓ in wilderness character
	Use of motor vehicles, motorized equipment, or mechanical transport	Number of administrative and nonemergency use of motor vehicles, motorized equipment, or mechanical transport	↑ in number = ↓ in wilderness character
		Number of emergency use of motor vehicles, motorized equipment, or mechanical transport	↑ in number = ↓ in wilderness character
		Number of motor vehicle, motorized equipment, or mechanical transport use not authorized by NPS-FIIS	↑ in number = ↓ in wilderness character
	Removal of remnants that remain in the wilderness from past occupation	Number of actions to remove remnants	↑ in number = ↑ in wilderness character
Solitude or ***Primitive*** and ***Unconfined Recreation*** Wilderness provides outstanding opportunities for people to experience solitude or primitive and unconfined recreation, including the values of inspiration and physical and mental challenge	Remoteness from sights and sounds of people inside wilderness	Amount of visitor use	↑ in visitor use = ↓ in wilderness character
		Number of areas negatively affected by camping	↑ in number of actions = ↓ in wilderness character
		Number of actions taken that affect travel routes inside the wilderness	↑ in number of actions = ↓ in wilderness character
	Remoteness from occupied and modified areas outside the wilderness	Area of wilderness affected by access or travel routes that are adjacent to the wilderness	↑ of people = ↓ in wilderness character
		Night sky visibility averaged over the wilderness	↑ in light pollution = ↓ in wilderness character
	Facilities that decrease self-reliant recreation	Number of agency-provided recreation facilities	↑ in number = ↓ in wilderness character
	User trail development	Number of actions taken to mitigate user trails	↑ in number of actions = ↓ in wilderness character
	Management restrictions on visitor behavior	Number of visitor use restrictions	↑ in number of restrictions = ↓ in wilderness character

Note: Based on concepts discussed in Landres et al. 2008a and 2008b.

Table 2. Example of wilderness character trend worksheet for evaluating natural quality

Indicator	Measure	Previous Year	Current Year	Trend in Measure	Trend in Indicator	Trend in Quality
1. Plant and animal species and communities	1a. Number of listed species	5	5	↕	↑	↑
	1b. Abundance of listed species	25	20	↓		
	1c. Number of invasive species	5	6	↑		
	1d. Acreage of invasive species	1.3	1.1	↑		
2. Physical resources	2a. Ozone (ppm)	0.060	0.055	↑	↑	
	2b. Water quality	50	48	↑		
3. Biophysical resources	3a. Forest health	0	0	↕	↓	
	3b. Salt Marsh Elevation	2.5	2.1	↓		

Note: Each measure is ranked based on the previous year (see ranking column for "Natural" in table 1). Each trend measure is simply added to each indicator to ultimately provide a trend for the quality.

sive plants such as Japanese black pine (*Pinus thunbergii*) will have an initial degrading effect on untrammeled quality. However, if the total acreage of nonnative invasive plants decreases along with the number of actions taken to remove them, wilderness character for both the untrammeled and natural qualities will improve (table 1). Unfortunately, degradation may also occur in cases over which the park has no control. For example, a law enforcement or emergency incident requiring mechanical devices to aid in life safety may negatively affect wilderness qualities.

Suggestions for protocol development

We learned a great deal in developing this protocol and would like to share our challenges to help other managers develop wilderness character monitoring protocols of their own. Our three main suggestions are to (1) hire a temporary employee to assist with developing and organizing the protocol, (2) use existing data and monitoring programs, and (3) form a wilderness committee within your park. Our park was able to develop a protocol using existing staff; however, the process proved to be lengthy and took more than two years. Dedicated temporary staff assigned to work with the team would expedite the process. Such a person could assist with establishing baseline inventories, identifying data sources for each measure, and creating a database to store the wilderness character monitoring data. Employing existing measures to the greatest possible extent was important for developing this tool. Although a few additional measures were created, the process is cost-effective and does not place an additional workload on park staff. We focused on measures that would be collected or monitored in the future by park staff, the Northeast Coastal and Barrier Network, or another governmental agency. Finally, a wilderness committee with all park divisions represented can make a clear plan with roles and responsibilities for collecting, submitting, and analyzing specific measures. Having a committee in addition to a working team helps ensure that the wilderness character monitoring protocol can still be followed and continued into the future in the face of staff turnover and budget constraints.

References

Landres, P., C. Barns, J. D. Dennis, T. Devine, P. Geissler, C. S. McCasland, L. Merigliano, J. Seastrand, and R. Swain. 2008a. Keeping It Wild: An interagency strategy to monitor trends in wilderness character across the National Wilderness Preservation System. General Technical Report RMRS-GTR-212. U.S. Forest Service, Rocky Mountain Research Station, Fort Collins, Colorado, USA.

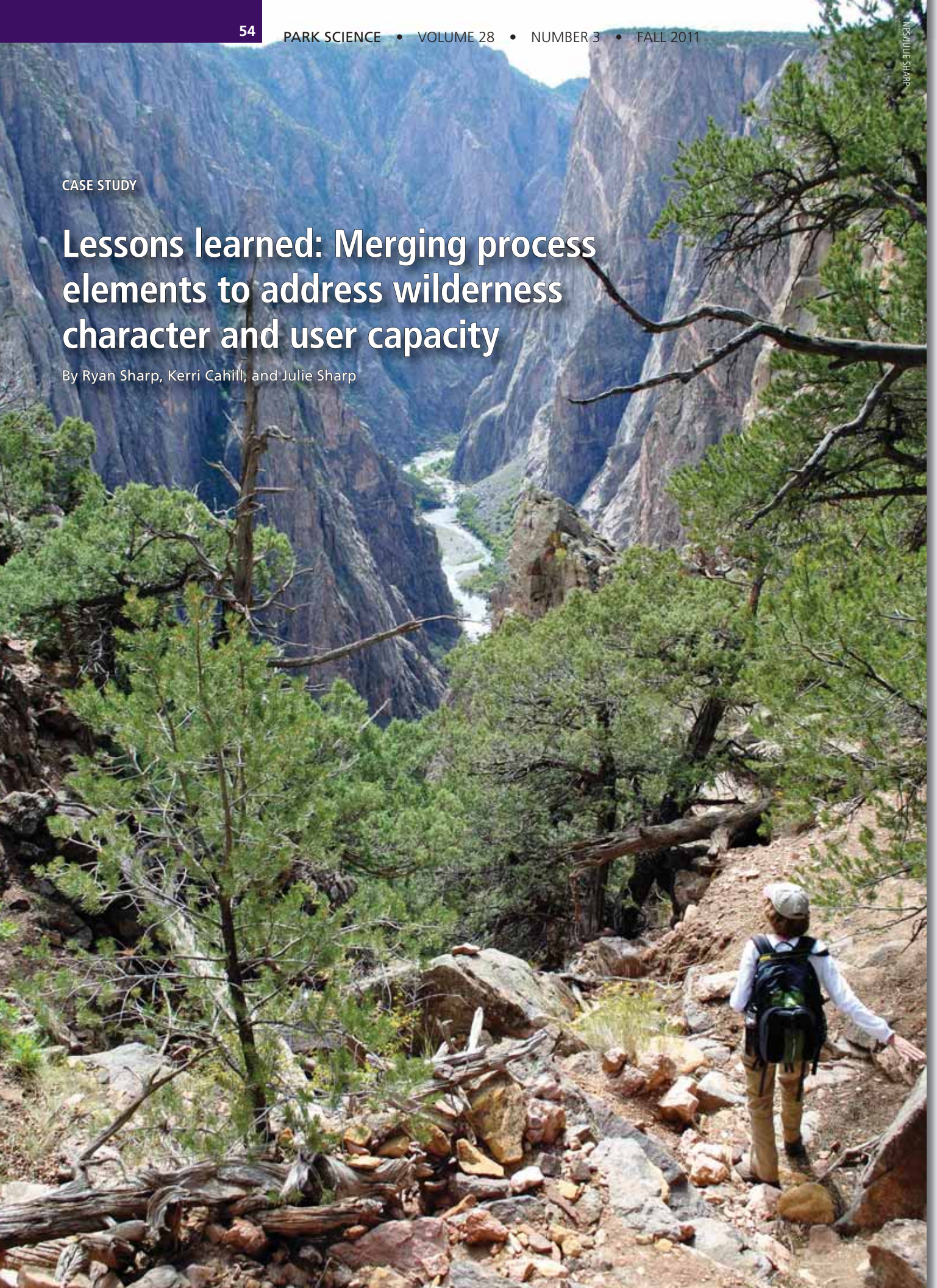
Landres, P., M. B. Hennessy, K. Schlenker, D. N. Cole, and S. Boutcher. 2008b. Applying the concept of wilderness character to national forest planning, monitoring, and management. General Technical Report: RMRS-GTR-217WWW. U.S. Forest Service, Rocky Mountain Research Station, Fort Collins, Colorado, USA.

Landres, P., S. Boutcher, T. Blett, D. Bumpus, T. Carlson, D. Cole, L. Dean, T. Hall, C. Hardy, A. Leach, A. Mebane, L. Merigliano, S. Rinehart, and P. Wright. 2009. Technical guide for monitoring selected conditions related to wilderness character. General Technical Report WO-80. U.S. Forest Service, Washington, D.C., USA.

Northeast Coastal and Barrier Network (NCBN). 2011. Vital signs: Salt marsh elevation. Web site. National Park Service, Inventory and Monitoring Program, Fort Collins, Colorado, USA. Accessed 2 December 2011 at http://science.nature.nps.gov/im/units/ncbn/vs/saltelevation.aspx.

About the authors

All authors are with the National Park Service, Fire Island National Seashore, New York. ***Lindsay Ries*** *is a wildlife biologist and can be reached by e-mail at lindsay_ries@nps.gov.* ***Jason Flynn*** *is a visitor and resource protection ranger.* ***Jordan Raphael*** *is a park biologist.*



NPS/JULIE SHARP

CASE STUDY

Lessons learned: Merging process elements to address wilderness character and user capacity

By Ryan Sharp, Kerri Cahill, and Julie Sharp

Abstract
The Wilderness Act of 1964 and the National Park Service (NPS) management policies require that conditions and long-term trends of wilderness character be monitored. This monitoring is based on the four key wilderness qualities: untrammeled, natural, undeveloped, and opportunities for solitude or primitive and unconfined recreation. The interagency "Keeping It Wild" framework was developed to guide wilderness character monitoring, but there has been limited application within the National Park Service to date. One of the primary reasons for this has been the need to develop specific guidance on implementing the framework and integrating it into agency planning efforts. As part of 2010 initiatives to develop guidance for "Keeping It Wild" field application, NPS staff found an opportunity to merge elements of the "Keeping It Wild" framework with the framework to address user capacity. Although the frameworks use slightly different terminology, the end goals are largely the same: to provide a process that guides planning and management to preserve resources while also protecting the visitor experience. In three case studies, some elements and methods of the processes to address wilderness character and user capacity were merged, resulting in lessons for guiding future wilderness stewardship planning and management.

Key words
indicators, measures, monitoring, standards, user capacity, wilderness character

WILDERNESS CHARACTER MONITORING SEEKS TO ANSWER the question, "How is wilderness character changing over time?" Similar but slightly different, user capacity approaches in wilderness evaluate "at what point . . . visitor use [is] causing undesirable impacts to wilderness resources and visitor experiences." There is a nexus between these questions as they relate to wilderness management. This article examines the similarities in approaches to addressing wilderness character and user capacity, and more specifically lessons learned from the respective processes in three planning examples.

Both the 1964 Wilderness Act and 2006 National Park Service (NPS) *Management Policies* require natural and cultural resource condition monitoring and long-term trend identification in wilderness character. This monitoring is based on the four wilderness qualities: untrammeled, natural, undeveloped, and opportunities for solitude or primitive and unconfined recreation. The interagency "Keeping It Wild" framework (Landres et al. 2008) was developed to monitor wilderness character, but there has been limited application within the Park Service to date.

Figure 1 (left). A hiker pauses to enjoy the view along one of the many routes into the wilderness area at Black Canyon of the Gunnison National Park, Colorado.

One of the primary reasons for this is the need to develop specific guidance on implementing the framework and integrating it into agency planning efforts. As part of 2010 initiatives to develop guidance for field application, NPS staff found an opportunity to merge elements of the "Keeping It Wild" framework with the framework to address user capacity. Although these frameworks use slightly different terminology, the end goals are largely the same: to provide a process that guides planning and management to preserve resources while also protecting the visitor experience. In three examples, some elements and methods to address wilderness character and user capacity were merged, resulting in lessons for guiding future wilderness stewardship planning and management.

Frameworks for wilderness character and user capacity assessments

Two separate but related frameworks exist within the National Park Service to monitor wilderness. The "Keeping It Wild" framework is an interagency strategy to monitor trends in wilderness character across the National Wilderness Preservation System (Landres et al. 2008). The purpose of the framework is to improve wilderness stewardship by offering managers a process for monitoring and assessing how wilderness character changes over time (Landres et al. 2008). The Visitor Experience and Resource Protection (VERP) framework offers a process for managing visitor use and related impacts to protect park resources and provide high-quality visitor experiences (NPS 1997). User capacity is defined as the type and level of visitor use that can be accommodated while sustaining the desired resource and visitor experience conditions in a park (NPS 2006). The VERP framework was developed to elevate the science and practice of planning for and managing user capacity beyond a focus on simply use limits into the larger arena of visitor use management. As such, this framework has been integrated into NPS planning processes and is now considered part of the agency's protocol to address user capacity rather than a stand-alone framework.

The general purposes of the two frameworks overlap and they also include some of the same basic elements (table 1, next page). At the core of both frameworks are measurable variables monitored to track changes in conditions over time and inform ongoing management. In fact, the concept of *measures* in "Keeping It Wild" is analogous to the concept of *indicators* in VERP. The wilderness character measures, and the equivalent concept of user capacity indicators, are defined as specific, measurable variables tracked to assess progress at attaining desired conditions and preserving wilderness character (Landres et al. 2008; NPS 1997). However, "Keeping It Wild" also uses the term "indicators." These indicators are at a more topical level than the measurable

Table 1. Basic elements of processes to address wilderness character and user capacity

Wilderness Character	User Capacity
1. Define desired conditions that are consistent with the park's wilderness qualities (the qualities are found in the Wilderness Act: untrammeled, natural, undeveloped, and opportunities for solitude and unconfined recreation).	1. Define desired conditions for resources and visitor experiences that are consistent with the park's purpose and significance.
2. Identify indicators and measures.	2. Identify indicators, standards, and management strategies.
3. Assess trends related to wilderness character.	3. Assess conditions related to visitor impacts.
4. Manage adaptively	4. Manage adaptively.

indicators identified in the VERP framework. In the context of wilderness character monitoring, indicators are defined as the distinct and important elements within each quality of wilderness character related to standard monitoring questions. For example, "actions authorized by the federal land manager that manipulate the biophysical environment" is one of the 13 indicators defined in "Keeping It Wild" and relates to evaluating the untrammeled quality (Landres et al. 2008). Standards, defined only in the VERP framework, are management decisions on the minimum acceptable condition for indicators and serve as triggers for management actions (NPS 1997). In "Keeping It Wild," standards are not identified, but rather measures are monitored to assess trends in conditions for wilderness character and to inform management decisions (Landres et al. 2008).

Although there are many similarities between the two frameworks, there are also differences. First, the "Keeping It Wild" framework is primarily a monitoring strategy, but it provides information that can inform wilderness stewardship planning and management. The VERP framework is broader in scope and includes the steps of visitor use planning, monitoring, and management. Second, the "Keeping It Wild" framework addresses a more comprehensive set of influences that include not only visitor use–related impacts but also the influence on wilderness character of agency management actions and surrounding land uses. However, when addressing user capacity, the focus is entirely on visitor use–related impacts on resources and visitor experiences.

Third, the "Keeping It Wild" framework provides a predetermined list of indicators with an associated menu of measures that park staff can choose from to best meet their needs. In contrast, when addressing user capacity, indicators are identified through a facilitated process of discovery with park staff, based on the issues and alternatives explored in the planning process. Although examples from parks with similar issues may be provided, typically no consistent menu of user capacity indicators is presented at user capacity workshops. Fourth and finally, as already noted, the "Keeping It Wild" framework focuses on monitoring trends that inform management decisions, whereas the VERP framework includes quantitative standards that trigger management action. Combining elements of the two processes in wilderness stewardship planning and management presents an opportunity to draw on the strengths of both to improve outcomes and better protect wilderness character.

Examples

The integration of the two processes was recently assessed by planning teams from three NPS regional offices (Intermountain, Alaska, and Pacific West); the Denver Service Center; and three parks: Black Canyon of the Gunnison National Park (Colorado, fig. 1), Gates of the Arctic National Park and Preserve (Alaska), and Death Valley National Park (California). Projects at these parks presented an opportunity to merge elements and methods from both processes to explore the effectiveness and efficiency of addressing wilderness character and user capacity in current planning efforts.

A combination of the basic elements outlined in table 1 was used during the different planning processes at each park (e.g., a general management plan at Gates of the Arctic and wilderness/backcountry management plans at Black Canyon and Death Valley). However, a consistent and general method was used in these various projects, adapted as detailed below:

1. Examine the suggested measures provided in "Keeping It Wild" (Landres et al. 2008) and the "Technical Guide for Monitoring Selected Conditions Related to Wilderness Character" (Landres et al. 2009).

2. Prioritize each potential wilderness character measure to determine its viability as a measure for the park.

3. Assign the measures to applicable management zones (which define desired conditions for resources and visitor experiences), develop standards for the selected measure, and identify appropriate management strategies for each measure.

Accordingly, in the three case studies, potential measures were either adopted or modified from those listed in these two publications. In addition, park staff was encouraged to add new measures

At the core of both frameworks are measurable variables monitored to track changes in conditions over time and inform ongoing management.

important to their particular wilderness, as appropriate. Each measure was scored on a scale of one (low) to three (high) based on four criteria, modified from typical user capacity workshops and the VERP framework (NPS 1997): (1) level of importance of the measure for protecting the associated wilderness character indicator and quality; (2) level of vulnerability of the measure of wilderness character (i.e., is it currently at risk or likely to be at risk over the next 10–15 years?); (3) degree of reliability of the measure to be monitored accurately with a high degree of confidence if measured by different people at different times; and (4) degree of reasonableness of monitoring without significant additional effort.

Lessons learned

Merging elements of the processes to address wilderness character and user capacity resulted in several lessons. First, the planning teams for all three projects tested a blend of methods when selecting wilderness character measures. In the workshops the suggested measures in "Keeping It Wild" were used as a starting point, providing focus and efficiency to the process. However, park staff was also encouraged to modify the measures or select new ones to best address the specific needs of their wilderness based on the issues and alternatives explored in the respective plans. The proposed measures were then evaluated based on criteria modified from those used in typical user capacity workshops and the VERP framework. These criteria helped ensure that the set of measures selected was both meaningful and practical for long-term monitoring.

Second, because these workshops were focused on the four wilderness qualities, it was unclear at the outset whether or not the outcomes would fully support the user capacity needs of the project. In particular, the degree to which visitor use–related impacts would be captured as part of the selection of wilderness character measures was unknown. In all three projects, however, the emphasis on tailoring the measures to specific wilderness needs and the planning effort seemed to result in a comprehensive list of visitor use–related measures that were similar to the indicators that would be identified in a user capacity workshop. These measures seem to provide sufficient guidance for the user capacity needs of the projects. Example measures are extent and magnitude of human-caused change in water quality, number and severity of human-caused disturbances to cultural resources, and number of encounters with other visitors.

Third, including standards for each measure as part of the process to address wilderness character seemed to help provide clearer direction for future management response. However, in all three projects the emphasis on quantitative standards when addressing user capacity was recognized as possibly insufficient in the context of wilderness character. Given the broad scope of the wilderness character measures across the four wilderness qualities, and that many of the conditions evaluated are outside of an agency's management control (e.g., impacts to night skies and air quality), some standards may need to be qualitative rather than quantitative. For some wilderness character measures, the standards may be qualitatively defined as a significant change in trends, which triggers the modification or initiation of management actions. However, most of the visitor use–related standards should be quantitative since management of visitor use is largely within the agency's management control.

Fourth, identification of a general menu of adaptive management strategies that relate to each wilderness character measure was also included in the planning process, which is another element borrowed from the process to address user capacity. For the most part, the addition of this element seemed useful to the planning project without much deviation from how it is approached in a user capacity workshop. However, at the Death Valley workshop, additional time was spent to identify more detailed visitor use management actions for specific areas in the park. These actions were tied directly to the visitor use–related measures and standards that had been defined earlier in the same workshop. Other project teams may find this additional level of detail useful, depending on the specific needs of the wilderness.

Finally, the Gates of the Arctic workshop highlighted special challenges that may be faced when applying the proposed measures from "Keeping It Wild" to a park in Alaska because of particular uses authorized under the Alaska National Interest Lands Conservation Act (e.g., airplanes and snow machines). Many measures from the "Keeping It Wild" framework were not applicable, and unique situations such as subsistence use did not fit well within the four qualities of wilderness. The workshop emphasized the need to maintain flexibility when applying methods from either process to ensure a meaningful outcome that directly addresses park needs.

Conclusion

The processes for addressing wilderness character and user capacity overlap in both concept and practice. Methods related to

both processes were merged at Black Canyon, Gates of the Arctic, and Death Valley and resulted in useful lessons for guiding field application. The suggested menu of measures from the "Keeping It Wild" framework should be the starting point for all workshops, along with an opportunity to refine and prioritize these measures based on the specific needs of the wilderness and the planning effort. The user capacity elements seem sufficiently addressed with the selection of wilderness character measures and standards structured around the four wilderness qualities, but more specific visitor use management actions may be needed in particular situations. Adding standards to the process for addressing wilderness character is a useful step that provides clearer direction on a management response, but these standards could be either qualitative or quantitative in the context of wilderness character. Finally, certain situations, such as in Alaska, may require a high level of flexibility when applying methods from either process. These case studies indicate that a combination of elements of these processes could create a meaningful and practical set of measures, standards, and management strategies that can support ongoing wilderness stewardship planning and management.

References

Landres, P., C. Barns, J. G. Dennis, T. Devine, P. Geissler, C. S. McCasland, L. Merigliano, J. Seastrand, and R. Swain. 2008. Keeping It Wild: An interagency strategy to monitor trends in wilderness character across the National Wilderness Preservation System. General Technical Report RMRS-GTR-212. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, Colorado, USA.

Landres, P., S. Boutcher, L. Dean, T. Hall, T. Blett, T. Carlson, A. Mebane, C. Hardy, S. Rinehart, L. Merigliano, D. Cole, A. Leach, P. Wright, and D. Bumpus. 2009. Technical guide for monitoring selected conditions related to wilderness character. General Technical Report WO-80. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, Colorado, USA.

National Park Service (NPS). 1997. The Visitor Experience and Resource Protection (VERP) framework. A handbook for planners and managers. U.S. Department of the Interior, National Park Service, Denver Service Center, Denver, Colorado, USA.

———. 2006. Management policies 2006. U.S. Department of the Interior, National Park Service, Washington, D.C., USA.

About the authors

Ryan Sharp *(ryan.sharp@eku.edu), PhD, is an assistant professor at Eastern Kentucky University, Department of Recreation and Park Administration.* ***Kerri Cahill*** *(kerri_cahill@nps.gov), PhD, is Visitor Use Management Team lead with the NPS Denver Service Center, Denver, Colorado.* ***Julie Sharp*** *(jsharp0703@gmail.com), MS, is a former employee of the National Park Service Intermountain Regional Office.*

PS

NEW TOOL

A database application for wilderness character monitoring

By Ashley Adams, Peter Landres, and Simon Kingston

THE NATIONAL PARK SERVICE (NPS) WILDERNESS Stewardship Division, in collaboration with the Aldo Leopold Wilderness Research Institute and the NPS Inventory and Monitoring Program, developed a database application to facilitate tracking and trend reporting in wilderness character. The Wilderness Character Monitoring Database allows consistent, scientifically based monitoring of trends in wilderness character throughout the National Park System and, potentially, throughout the National Wilderness Preservation System. Furthermore, the database allows the Park Service to track whether wilderness character is improving, stable, or degrading at the local, regional, or national level.

Why is this significant? The National Park Service is mandated by the 1964 Wilderness Act to protect and preserve wilderness character in designated wilderness. The Park Service must know the ongoing status of wilderness character to evaluate whether or not it is being preserved. Until the development of the wilderness character database in 2011, there was no national systematic effort to monitor wilderness character. Some national parks with strong wilderness stewardship programs tracked particular aspects of wilderness character, such as visitor numbers and the opportunity for solitude, but these efforts were not coordinated across the system and did not fully address the broad spectrum of qualities that underpin wilderness character.

The database has three main objectives: (1) to facilitate wilderness character tracking and reporting at the local, regional, and national levels, (2) to establish a framework for national consistency on overall wilderness qualities monitored, and (3) to allow flexible autonomy at the individual wilderness level through unique measure selection.

The database is based on the monitoring framework from "Keeping It Wild: An Interagency Strategy to Monitor Trends in Wilderness Character Across the National Wilderness Preservation System" (Landres et al. 2008). Like the strategy, the hierarchical database design breaks wilderness character down into four universal qualities: untrammeled, natural, undeveloped, and solitude or primitive and unconfined recreation.

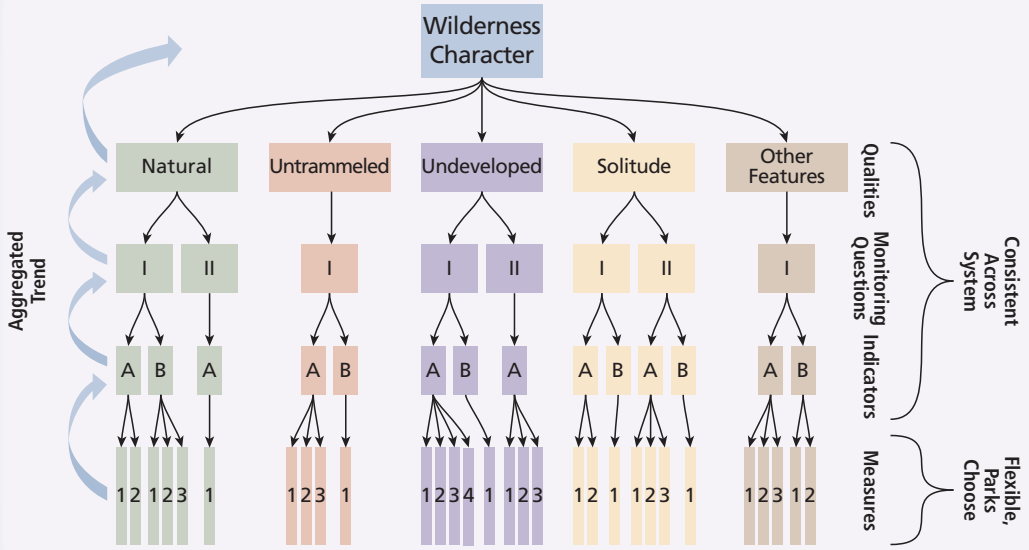


Figure 1. Hierarchical structure of the wilderness character database. Wilderness character is broken down into five qualities, which are then further categorized into monitoring questions, indicators, and measures. The database is standardized from the qualities down to the indicator level; measures are flexible and are chosen on a park-by-park basis. Trend is aggregated at each level from the level directly below, converging into the overall trend for wilderness character at the top.

Diverging from "Keeping It Wild," the Park Service also breaks wilderness character down into a fifth quality: other features. Each of these qualities is further divided into a set of monitoring questions, which are subcategorized into indicators, then monitoring measures (e.g., Character → Qualities → Monitoring Questions → Indicators → Measures) (see fig. 1).

The database is standardized from the qualities down to the indicator level. However, measures are flexible and can be unique to each wilderness area. For example, one wilderness may choose the population size of grizzly bears as a measure for the "plant and animal species and communities" indicator under the natural quality, while another wilderness may choose the total number of native mammal species found within its boundaries. Appropriate measures are chosen at the park unit level, ideally with guidance from regional and national levels.

The trend in wilderness character is initially assessed at the measure level. At each higher level, the trend is "rolled up," or aggregated, from the previous level based on rules for combining trends published in "Keeping It Wild" (Landres et al. 2008). The database shows trend interaction and how a management action in one measure, or a combination of management actions across multiple measures, affects trend direction on multiple levels.

Managers can track and report the condition of the measure, although only the trends in wilderness character are aggregated. Additionally, at every level, managers can comment on the underlying reasons for data and trends to better clarify why those trends are occurring.

When the wilderness character database is fully implemented (target date 2014), each park will house a database for each wilderness area within its jurisdiction, and will electronically submit its database(s) annually to the national office for aggregate, macro trend evaluation. Notably, database trends are not comparable among wilderness areas because of the unique aspects of each wilderness.

Additional information about the wilderness character database application will be made available in the future in the form of a user guide being developed by the Wilderness Character Integration Team.

Reference

Landres, P., C. Barns, J. G. Dennis, T. Devine, P. Geissler, C. S. McCasland, L. Merigliano, J. Seastrand, and R. Swain. 2008. Keeping It Wild: An interagency strategy to monitor trends in wilderness character across the National Wilderness Preservation System. General Technical Report RMRS-GTR-212. USDA Forest Service, Fort Collins, Colorado, USA.

About the authors

Ashley Adams *is a natural resource specialist with the NPS Wilderness Stewardship Division in Washington, D.C. She can be reached at (202) 513-7130 and ashley_adams@nps.gov.* ***Peter Landres****, PhD, is an ecologist and Research Application Program leader with the Aldo Leopold Wilderness Research Institute, Missoula, Montana. He can be reached at (406) 542-4189 and plandres@fs.fed.us.* ***Simon Kingston*** *is a data manager with the NPS Inventory and Monitoring Division in Fort Collins, Colorado.*

Contributed Articles

STATE OF SCIENCE

The science of trail surveys: Recreation ecology provides new tools for managing wilderness trails

By Jeffrey L. Marion, Jeremy F. Wimpey, and Logan O. Park

Figure 1. Authors Logan Park (left) and Jeremy Wimpey assess a trail in Acadia National Park, Maine.

THIS ARTICLE REVIEWS RECENT RECREATION ECOLOGY research focused on developing new survey methods for assessing formal and informal trails or unsurfaced roads in wilderness and backcountry settings (fig. 1). Recreation ecology examines resource impacts caused by or related to visitor use. A brief review of research related to trail sustainability is included to illustrate factors that influence common types of trail degradation. These studies are producing new information and tools for park managers engaged in trail, carrying capacity, and other park planning and management decisions. Results can document the nature and severity of trail impacts and design deficiencies for planning and management decision making. For example, such data can justify staffing and funding requests to improve trail sustainability by relocating or reconstructing the worst trail segments, which will lower recurring maintenance costs.

Many park trails, especially those created before the advent of modern trail construction guidelines, were not sustainably designed. It is not surprising, therefore, that some park wilderness and backcountry trail systems quickly degrade under heavy traffic (fig. 2). A survey of National Park Service (NPS) backcountry and wilderness managers found that trail impacts were regarded as the most severely pervasive visitor impact problem, with 50% of all parks reporting trail impacts occurring in most or many areas (Marion et al. 1993). The most common trail impacts reported by park staff included soil erosion (44% of parks), trail widening (31%), braided/multiple trails (29%), informal trails (29%), and excessive muddiness (25%). These trail-related impacts are of great concern in wilderness areas (Abbe and Manning 2007), which are managed to maintain resource conditions that are "untrammeled by man … protected and managed so as to preserve [their] natural conditions" (16 USC 1131–1136). Moreover, trails that are designed or reworked to meet sustainability guidelines can reduce future maintenance costs and conflicts with the "minimum tool" wilderness management requirements.

Abstract
Recreation ecology examines the effects of recreation on protected area ecosystems. One core focus of recreation ecology research is trail science, including the development of efficient protocols to assess and monitor the type and severity of resource impacts, analyses to improve knowledge of factors that influence trail conditions, and studies to assist land managers in improving trail design, maintenance, and visitor management. This article reviews alternative trail survey methodologies most useful for the management of wilderness and backcountry trail networks. Illustrations and implications from survey data for trail planning, design, and management are included.

Key words
sustainable trail design, trail impacts, trail survey methods

JEFF MARION

Figure 2. Hikers on a wide, eroded trail along the Blue Ridge Parkway, Virginia.

Recreation ecology and trail science

Regression modeling and other relational analyses used to investigate trail degradation reveal the influence of various factors on the sustainability of a trail to traffic (Leung and Marion 1996; Nepal 2003). Soil loss, generally considered to be the most significant and irreversible form of trail impact, is highest when trails have steep grades and are parallel to the landform grade or aspect, called fall-line alignments (Olive and Marion 2009). Steep trail grades accelerate soil erosion, and incised fall-aligned trails trap and channel water directly down their treads. The amount of rock in trail substrates and the density and effectiveness of tread drainage features (e.g., water bars, grade reversals, outsloped treads) are also important factors affecting soil loss. Regression modeling reveals that sustainable designs can also effectively reduce trail widening, which impacts adjacent vegetation and soil. Steep fall-aligned trails permit and even encourage the lateral movement of hikers, which widens trails, particularly when soil erosion produces incised treads with significant rockiness and root exposure (Wimpey and Marion 2010). Trail widening and the formation of multiple braided treads are also common in flat, poorly drained terrain, particularly when hikers seek to avoid wet and muddy conditions. In contrast, side-hill constructed trails, particularly when crossing steeper landform grades, effectively constrain trail widths.

Three types of trail surveys

Traditionally implemented with measuring wheels and data recorded on paper forms, trail surveys increasingly use global positioning system (GPS) devices to locate and map inventory data with a high degree of accuracy. GPS collection allows for electronic data entry, which enables direct downloads of trail data to computers, saving much time and avoiding recording and transcription errors. Three general types of trail surveys have been developed to assist in managing trail systems:

- Trail attribute inventory
- Trail condition assessment
- Trail prescriptive management assessment

A **trail attribute inventory** uses professional-grade GPS units to map *trail system characteristics*, providing accurate geographic information systems (GIS) trail layers for mapping, planning, analytical, and decision-making functions. Common trail attribute data are use type, cultural/historical features, attraction features, hiking difficulty and accessibility, maintenance features (e.g., signs, gates/barriers, bridges, culverts/water bars), and sustainability attributes (e.g., trail grade, slope alignment angle, slope ratio, trail substrates). Inventories of informal trail networks provide data on their spatial distribution and aggregate lineal and areal extent.

Trail attribute inventories can provide highly accurate GIS formal and informal trail layers. During the field survey, attributes such as use type and tread substrates can be associated with each line segment. Point features, such as gates, bridges, campsites, and vistas, can be collected and assigned attributes, and even digital photos can be linked and geo-referenced to these points. At Chesapeake and Ohio Canal National Historical Park, survey-grade GPS units were used to inventory and map 14.7 miles (23.7 km) of formal trail and a surprising 19.3 miles (31.1 km) of informal trails, posing a direct threat to the park's many rare plant species. Trail inventory data are useful for general management, trail, wilderness, and carrying capacity planning; mapping and GIS analyses; and

JEREMY WIMPEY

Figure 3. A Trimble GPS was used to map all formal trails (blue) and informal trails (red) in the Potomac Gorge area of C&O Canal National Historical Park.

park management decision making. Analysis of trail grade and slope ratio for sustainability can be conducted by combining trail inventory data with high-resolution terrain models (such as lidar-derived terrain models). In the wilderness setting, these high-tech analyses can represent the minimum tool by allowing managers to minimize field time while providing the ability to assess vast trail systems electronically in the GIS environment (fig. 3).

Trail condition assessments document trail resource conditions to provide data on the type, severity, and, in some surveys, location of specific types of *trail impacts*. A commonly applied *point sampling survey* method assesses trail conditions at transects established at a fixed interval (e.g., every 300 or 500 ft [92 or 153 m]), following a randomly selected first point (Cole 1991; Marion and Leung 2001). This approach provides excellent data for characterizing and monitoring continuous trail attributes (trail width) or common impacts (trail incision/soil loss) (table 1). Data can be compared against quantitative Limits of Acceptable Change/Visitor Experience and Resource Protection framework standards of quality or simply evaluated to determine where and how much trail conditions are changing over time.

A *problem assessment survey* provides census data by recording every occurrence of predefined impact problems, such as excessive trail width, soil loss, or muddiness (Leung and Marion 1999) (table 2). Other attributes, such as the efficacy of tread drainage

Table 1. Point sampling condition assessment data for two park trails in Zion National Park, Utah

Indicator	West Rim Trail		LaVerkin Trail	
Trail width (mean, in [cm])	41.9	[106.4]	45.7	[116.1]
Max incision (mean, in [cm])	1.9	[4.8]	3.2	[8.1]
Area of disturbance (ft² [m²])	178,192	[16,572]	97,768	[9,092]
Soil loss				
Mean, in² [cm²]	36.1	[233]	92.4	[596]
Sum, yd³ [m³]	473	[362]	609	[466]
Yd³/mi [m³/km]	49	[23]	125	[59]
Trail substrates[1]				
Exposed soil (%)	64.2		88.3	
Exposed rock (%)	20.2		5.8	
Vegetation cover (%)	3.3		1.5	
Muddiness (%)	3.5		0	

Source: Marion and Hockett 2008.
[1]Proportion of trail transect width.

features, can also be included. This method provides useful location data for directing trail maintainers seeking to remedy impacts, and better characterizes less common forms of trail impact such as mudholes and braided trails.

Condition class surveys apply impact ratings based on written descriptions of increasing levels of trail impact to characterize sections of trails with similar conditions (Wimpey and Marion 2011). Higher ratings connote greater trail impact. This highly efficient survey method is most commonly applied to informal trail networks to map and track the number of trail miles by impact class. At Denali National Park (Alaska) this procedure was implemented as part of a suite of trail inventory and assessment procedures, allowing for rapid and cost-effective monitoring of informal trails across several million acres (fig. 4, page 64).

Trail prescriptive management assessments can evaluate and document *maintenance needs, sustainability attributes, use-type capabilities, and relocation options*. *Prescriptive maintenance work logs* can document the condition of or work needed on existing trail features, or the need for new features, including gates/barriers, bridges, signs, and tread drainage features (culverts, water bars, ditching) (Williams and Marion 1992). Work log assessments must be applied by experienced trail professionals, who prescribe the specific types of trail work needed and provide materials and labor estimates (table 3).

Sustainability analyses are currently being developed to collect and analyze data on trail grade, trail alignment angle to the prevailing landform grade, and tread substrates. Such analyses can be conducted with data from walking surveys, but when available, high-resolution topographic data derived from airborne lidar sen-

Table 2. Problem assessment condition data for the Spence Field to Doe Knob portion (7.7 mi) of the Appalachian Trail in Great Smoky Mountains National Park, Tennessee and North Carolina

	Occurrences		Total Lineal Distance		
Indicator	no.	no./mi (km)	ft (m)	ft/mi (m/km)	%
Soil loss: 1–1.9 ft (0.3–0.6 m)	30	3.9 (2.4)	6,065 (1,850)	788 (149)	15.0
Soil loss: 2–2.9 ft (0.3–0.9 m)	2	0.3 (0.2)	96 (29)	12 (2)	0.2
Excessive grade: >20%	6	0.8 (0.5)	2,357 (719)	306 (58)	5.8
Multiple treads	21	2.7 (1.7)	1,218 (371)	158 (30)	3.0
Excessive width: 3–6 ft (0.9–1.8 m)	15	1.9 (1.2)	1,455 (444)	189 (36)	3.6
Excessive width: >6 ft (1.8 m)	4	0.5 (0.3)	289 (88)	38 (7)	0.7
Wet soil	11	1.4 (0.9)	1,411 (430)	183 (35)	3.5
Drainage features					
Ineffective	110	14.2 (8.8)			
Intermediate	46	6.0 (3.7)			
Effective	65	8.4 (5.2)			

Source: Marion 1994.

sors offer a more promising option for conducting detailed evaluations. Lidar-based techniques are a subject of current research to develop GIS analyses for efficiently evaluating the sustainability of entire trail systems. Such data can also facilitate the development and application of criteria for evaluating the amount and type of use trails can accommodate, and relocation alternatives for trail segments that receive low sustainability scores.

Initial work has applied lidar data to assess trail grades (Keen 2011) and trail sustainability based on trail grades and topographic alignments (Wimpey 2011). Figure 5 (next page) illustrates exploratory analyses using high-resolution terrain models for assessing trail sustainability. U.S. Forest Service and National Park Service units in Georgia and West Virginia have employed lidar analyses of existing trail and road systems as part of assessment and planning efforts. On the Chattahoochee-Oconee National Forest, a lidar terrain model provided data to assess trail grades at an off-road vehicle trail system. Trail planners working with the National Park Service to develop a trail system in New River Gorge National River (West Virginia) evaluated preexisting extraction routes (old logging, mining, and agricultural roads) for sustainability and inclusion in a new trail system. Routes were collected via GPS and digitization from historical aerial imagery and evaluated for grade and slope ratio using lidar terrain models collected by the state and the U.S. Army Corps of Engineers.

Depending on the needs at a given park, any combination of trail attribute inventory, condition assessment, and prescriptive management survey can be used. For example, a trained GPS field technician (or two-person team) can conduct an initial baseline trail attribute inventory for park maintenance records and planning efforts. Since the expense and time are related primarily to getting staff on location as opposed to data collection, adding a condition assessment increases total cost very little. In combination, these methods provide more comprehensive and detailed documentation of trail resource conditions and management needs. Such data can guide management teams in planning and decision making by providing relevant quantitative data on many aspects of trail infrastructure, in addition to detailed GIS maps of trail system, trail conditions, problem locations, and sustainability evaluations.

Table 3. Prescriptive worklog summary for the Thunder Mountain Trail (2.4 mi), Delaware Water Gap National Recreation Area, New Jersey

Item	Units	Linear Feet (m)	Estimated Labor (hrs)
Steps	41	n/a	68
Step-stones	8	n/a	6
Ditching	20	187 (57)	29
Water bar	14	103 (31)	22
Bridge	2	56 (17)	188
Bog bridge	44	350 (107)	80
Side-hilling	355	n/a	28
Total			421

Source: Williams et al. 1992.

Discussion

Application of improved trail survey methodologies for collecting spatially referenced data and new technologies, particularly accurate GPS units, lidar-derived high-resolution terrain models, and advanced GIS software, offers substantial promise for the

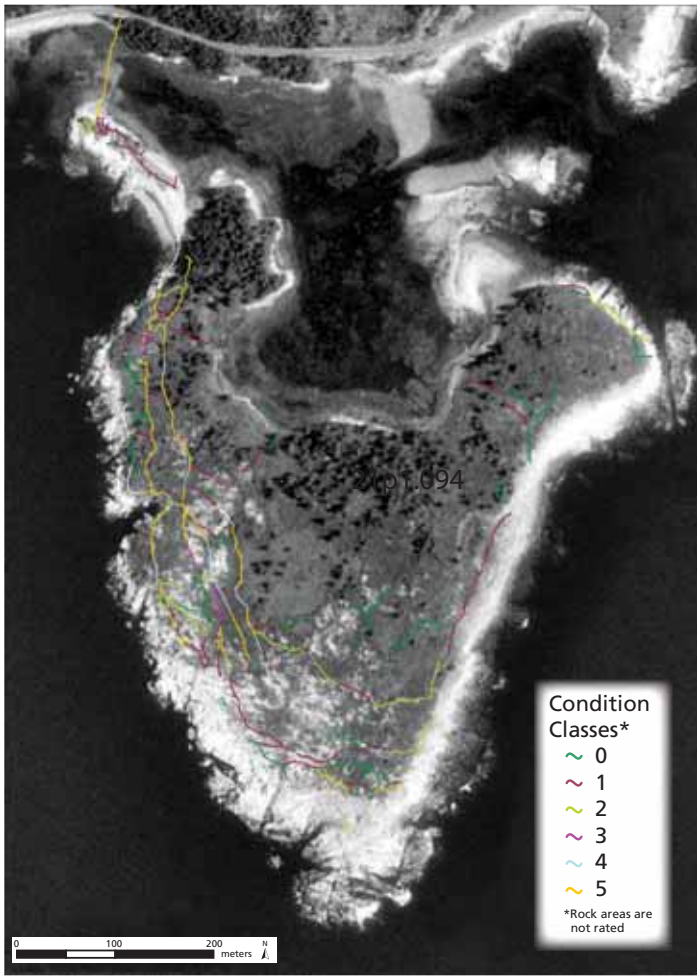
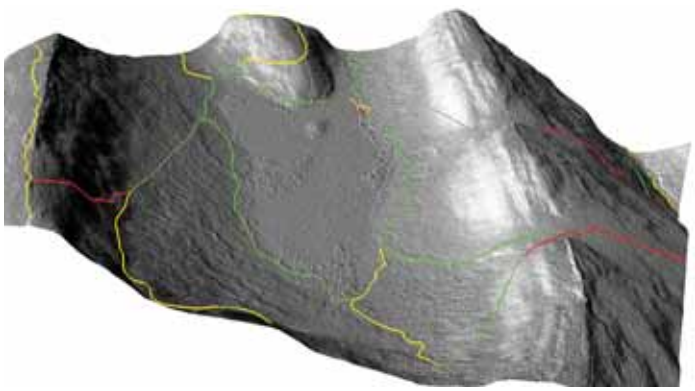


Figure 4. Condition class ratings applied to a mapped informal trail network in the Savage Box area, Denali National Park (above, top), and on Little Moose Island, Acadia National Park (above, bottom) (Marion and Wimpey 2011; Manning et al. 2006).

DENALI: JEREMY WIMPEY; ACADIA: ACADIA NATIONAL PARK GIS PROGRAM



JEREMY WIMPEY

Figure 5. Sustainability ratings derived from lidar data and GIS analytical evaluations of trail slope ratios: red = nonsustainable, yellow = borderline, green = sustainable (Wimpey 2011).

continuation of this work. While limited funding is a significant barrier, there are exciting scientific and managerially useful topics deserving of greater research attention. Current research is exploring the capabilities of new geospatial data sets and analyses and their ability to locate, characterize, and assess trail systems. Recent work has shown that formal and some informal trails can be mapped and analyzed directly from lidar data (Kincey and Challis 2010). The development of such tools will improve the ability of managers to remotely evaluate existing and proposed trails and trail systems, reducing staff time in the field.

Though vegetation, wildlife, and recreation management programs in parks are generally "science-based," trail management and its associated literature have traditionally not been based on scientific research. Though few in number, recreation ecology scientists are increasingly focused on expanding trail science knowledge, including development of trail survey methods, trail condition assessment protocols, and the relational analyses needed to identify and understand factors influencing trail degradation. This work continues to translate scientific information into usable knowledge for park managers, particularly as it relates to assessing and improving the sustainability of trail systems.

Park managers can integrate components from any of the three trail survey options described, and many of the tools and kinds of expertise needed are present in parks (e.g., survey-grade GPS units, clinometers, GIS software). Where needed, resource management and GIS staff can train seasonal field staff to collect data, even as a collateral duty. Lidar data can be contracted or obtained from a variety of sources. The authors have helped many national parks and other protected areas to develop and implement monitoring based on these techniques, with training materials and support provided to sustain the monitoring effort.

Sustainable [trail] designs can also effectively reduce trail widening, which impacts adjacent vegetation and soil.

Literature cited

Abbe, J. D., and R. E. Manning. 2007. Wilderness day use: Patterns, impacts, and management. International Journal of Wilderness 12(3):21–25, 38.

Cole, D. N. 1991. Changes on trails in the Selway-Bitterroot Wilderness, Montana, 1978–89. USDA Forest Service Research Paper INT-450. U.S. Department of Agriculture, Intermountain Research Station, Ogden, Utah, USA.

Keen, W. 2011. Beasley Knob OHV Trail System: Inventory, Assessment, and Management Plan. Developed by Trail Dynamics with assistance from Kay-Linn Enterprises, Applied Trails Research, and Georgia Bounty Runners for the USDA Forest Service, Chattahoochee-Oconee National Forest, Blue Ridge Ranger District.

Kincey, M., and K. Challis. 2010. Monitoring fragile upland landscapes: The application of airborne LiDAR. Journal for Nature Conservation 18(2):126–134.

Leung, Y. F., and J. L. Marion. 1996. Trail degradation as influenced by environmental factors: A state-of-the-knowledge review. Journal of Soil and Water Conservation 51(2):130–136.

———. 1999. Assessing trail conditions in protected areas: Application of a problem assessment method in Great Smoky Mountains National Park, U.S.A. Environmental Conservation 26(4):270–279.

Manning, R., C. Jacobi, and J. L. Marion. 2006. Acadia National Park visitor use and impact monitoring programs for carrying capacity decision-making. George Wright Forum 23(2):59–72.

Marion, J. L. 1994. An assessment of trail conditions in Great Smoky Mountains National Park. Final Research Report. USDI, National Park Service, Southeast Region, Atlanta, Georgia, USA.

Marion, J. L., and K. Hockett. 2008. Trail and campsite monitoring protocols: Zion National Park. Final Research Report. USDI, U.S. Geological Survey, Virginia Tech Field Station, Blacksburg, Virginia, USA.

Marion, J. L., and Y. F. Leung. 2001. Trail resource impacts and an examination of alternative assessment techniques. Journal of Park and Recreation Administration 19(3):17–37.

Marion, J. L., J. W. Roggenbuck, and R. E. Manning. 1993. Problems and practices in backcountry recreation management: A survey of National Park Service managers. NPS Natural Resources Report NPS/NRVT/NRR-93/12. USDI, National Park Service, Natural Resources Publication Office, Denver, Colorado, USA.

Marion, J. L., and J. Wimpey. 2011. Informal trail monitoring protocols: Denali National Park. Final Research Report. USDI, U.S. Geological Survey, Virginia Tech Field Station, Blacksburg, Virginia, USA.

Nepal, S. K. 2003. Trail impacts in Sagarmatha (Mt. Everest) National Park, Nepal: A logistic regression analysis. Environmental Management 32(3):312–321.

Olive, N. D., and J. L. Marion. 2009. The influence of use-related, environmental and managerial factors on soil loss from recreational trails. Journal of Environmental Management 90(3):1483–1493.

Williams, P. B., and J. L. Marion. 1992. Trail inventory and assessment approaches applied to trail system planning at Delaware Water Gap National Recreation Area. Pages 80–83 *in* G. A. Stoep, editor. Proceedings of the 1992 Northeastern Recreation Research Symposium. 5–7 April 1992, Saratoga Springs, New York. General Technical Report NE-176. USDA Forest Service, Northeastern Forest Experiment Station, Radnor, Pennsylvania, USA.

Williams, P. B., J. L. Marion, and R. Rajala. 1992. A comprehensive trail inventory and recommendations for development and maintenance of a trail system in Delaware Water Gap National Recreation Area. Final Research Report. USDI, National Park Service, Mid-Atlantic Region, Philadelphia, Pennsylvania, USA.

Wimpey, J. 2011. Unpublished exploratory analyses of trail sustainability using LiDAR data and GIS analyses. Applied Trails Research, State College, Pennsylvania, USA.

Wimpey, J., and J. L. Marion. 2010. The influence of use, environmental and managerial factors on the width of recreational trails. Journal of Environmental Management 91:2028–2037.

———. 2011. A spatial exploration of informal trail networks within Great Falls Park, VA. Journal of Environmental Management 92:1012–1022.

About the authors

Jeffrey L. Marion *is a recreation ecologist with the USGS Patuxent Wildlife Research Center at Virginia Tech in Blacksburg, Virginia. He can be reached by phone at (540) 231-6603 and by e-mail at jmarion@vt.edu.* ***Jeremy F. Wimpey*** *is the principal of Applied Trails Research in State College, Pennsylvania. He can be reached at (443) 629-2630 and by e-mail at jeremyw@appliedtrailsresearch.com.* ***Logan O. Park*** *is an assistant professor in the Department of Forestry at Southern Illinois University in Carbondale, Illinois. He can be reached at (618) 453-7476 and by e-mail at logan.park@siu.edu.*

NPS/DANIEL SILVA

STATE OF SCIENCE

Wilderness visitor experiences: A selective review of 50 years of research

By David N. Cole

Abstract
Two of the foremost conclusions from 50 years of research on wilderness visitors are that experiences are highly idiosyncratic and visitors are highly adaptable. The reasons people visit wilderness, their experiential aspirations, and their experiences in wilderness vary greatly among people and within people from visit to visit. Along with people's adaptability to the conditions they find in wilderness, this diversity challenges managers in their efforts to provide high-quality wilderness experiences. Despite the existence of extensive research literature, managers seeking to steward wilderness experiences still must make difficult decisions about who and what they are managing for.

Key words
solitude, wilderness experience, wilderness visitors

People vary in the experiences they seek and there is little evidence that the experiences sought depend exclusively on a wilderness to be realized.

WILDERNESS PRESERVATION IS A RECENT PHENOMENON. The first wilderness was designated in the United States in 1924 but wilderness legislation was not passed until 1964. The wilderness idea acknowledged a new relationship between people and land, both in how wilderness lands were to be managed and in the experiences people might have on wilderness visits. The history of research on wilderness experiences is a short one. The first study of wilderness visitors was conducted in 1956 and 1958 (Bultena and Taves 1961) in the Quetico-Superior region (now Boundary Waters Canoe Area Wilderness and Quetico Park in Canada). Visitors to the same area were more comprehensively studied by Lucas (1964) starting in 1960. Also in 1960, visitor surveys were conducted in seven "wildernesses" under the auspices of the Outdoor Recreation Resources Review Commission: Mount Marcy in the Adirondacks (New York), Great Smoky Mountains (Tennessee and North Carolina), Boundary Waters Canoe Area (Minnesota), Yellowstone-Teton (Wyoming), Bob Marshall (Montana), Gila (New Mexico), and High Sierra (California) (Outdoor Recreation Resources Review Commission 1962).

Reviewing these and other pioneering studies reveals motivations for studying wilderness visitors and provides initial glimpses of themes, perspectives, and methods still explored in 2011. Pioneering wilderness researchers believed there was something unique about a wilderness experience and were concerned that this experience was rare and at risk—that management was necessary to maintain high-quality wilderness experiences and that appropriate management required good research (Lucas 1964). Consequently, they and succeeding generations built a body of research to address (1) what visitors experience in wilderness, (2) influences on the nature or quality of these experiences, and (3) how managers can protect and enhance visitor experiences. This article reviews approaches to answering these questions, what has been learned, and what research results suggest regarding the stewardship of wilderness experiences. This selective review emphasizes experiential influences subject to managerial control and recent research of the author and his colleagues.

The nature of wilderness experiences

A wide range of research approaches and paradigms have been employed to gain insight into the nature of wilderness experiences. Researchers have most often treated wilderness experiences as discrete events and conceived of them as the psychological outcomes desired or attained from a wilderness visit (as if people knew exactly what was expected and desired from their visits). Other researchers have attempted to understand experience as a long-term phenomenon (as relationship, for example), have conceived of experience as emergent (as if people had little idea of what was expected or desired) and multiphasic, and have attempted to learn as much about the process of experience as about the outcome (Borrie and Birzell 2001).

Early insights into wilderness experiences arose from attempts to understand why people visited wilderness. In the Boundary Waters Canoe Area Wilderness, Bultena and Taves (1961) reported that the most prevalent motives involved adventure and exploration, struggling with the elements, and experiencing a less artificial setting away from the cares of the workaday world, while Lucas (1964) found that people visited to find solitude, be with members of their group, learn about the area, and commune with nature. Over subsequent decades, motives have been studied more systematically (Roggenbuck and Driver 2000). These stud-

(Left). Trails such as this one in the Shenandoah Wilderness, Virginia, provide access to many wilderness destinations and influence visitors' experiences of these places. When photographer Daniel Silva stopped to make this photo in the rain, all he could hear besides his own breathing was the sound of rain hitting the trees overhead. "It was a very serene experience," he explains. The photo was a runner-up in the recent *Park Science* wilderness photo contest.

ies suggest that there are common motives for visiting wilderness, such as solitude and experiencing nature, but that not all motives are shared. People vary in the experiences they seek and there is little evidence that the experiences sought depend exclusively on a wilderness to be realized (Stankey and Schreyer 1987).

Since the 1960s, studies have moved beyond motives to more deeply explore visitor experience as the thoughts, emotions, and physical feelings that arise from visitors' activities, their physical and social context, and their focus of attention. This research reveals much about the rich, varied, and fulfilling experiences that almost everyone has in wilderness. Although people's experience is highly varied—involving different activities and types of places—the focus of attention is most commonly on the natural environment as shared with other people in one's group. Focus on self is less prevalent (Hall et al. 2007) but nevertheless, dimensions such as challenge, inspiration, and exploration are important (Dawson et al. 1998). Despite commonalities, experiences are idiosyncratic, "influenced by individuals' unique identities, their current personal projects, recent past experiences, and situational influences" (Patterson et al. 1998, p. 244).

Experiences are emergent to a substantial degree, as well as dynamic, varying across the wilderness visit (Borrie and Roggenbuck 2001). This suggests the limitation of characterizing experience quality in a single discrete rating or as the degree to which preconceived expectations for desired experiences are met.

Some work has explored the long-term benefits that accrue from discrete wilderness visits. This perspective is inherent to the conceptual work of Driver and associates regarding the benefits that accrue from recreational experiences (Roggenbuck and Driver 2000). Others have employed a relationship metaphor to understand experience and found that some visitors value their long-term relationships to places or to wilderness experiences more than they do the attributes of a particular place or wilderness visit in isolation (e.g., Brooks et al. 2006).

Given the centrality of the concept of solitude in the Wilderness Act, much attention has been devoted to it. "Solitude" is the one word, beyond the mandate to provide for primitive and unconfined types of recreation, used to describe the type of experience wilderness should provide. To psychologists solitude means being alone, without intrusions, where others cannot observe you. Since few wilderness visitors choose to be alone, Hammitt (1982) has argued that the broader psychological concept of privacy is more aligned with the intent of the Wilderness Act. If there is a high degree of privacy, wilderness visitors can freely choose how much and what type of interaction with others they want. Cole and Hall (2008b) report results suggesting that solitude is valued but is often not viewed as critical to having a "real wilderness experience." Notably, solitude is not an "all-or-nothing" phenomenon; it can be intermittently experienced even in the most heavily used places in wilderness; it can be experienced in some places if not in others—perhaps at the campsite rather than along the trail (Hall et al. 2007).

"Solitude" is the one word [in the Wilderness Act], beyond the mandate to provide for primitive and unconfined types of recreation, used to describe the type of experience wilderness should provide.

Influences on the nature and quality of wilderness experiences

Most of the wilderness research on attributes that influence experience quality has been devoted to the effects of amount of use, as it was assumed that increasing use was the primary threat to quality wilderness experiences. Thus this review focuses on this attribute. However, many other attributes also affect experiences, including visitor behavior and environmental characteristics (Hockett and Hall 1998). For example, Schroeder and Schneider (2010) report that wildland fire promoted interest and exploration without resulting in much change in route choice or overall trip planning. Much remains to be learned about effects of invasive species, climate change, and other environmental influences on wilderness experiences.

Studies conducted both inside and outside wilderness have typically found a weak relationship between amount of use and overall quality of visitor experiences (often referred to as total satisfaction). This lack of relationship has often been dismissed as the result of conceptual and methodological issues that render satisfaction an inappropriate criterion to manage use levels (Manning 2011). However, in a study that overcame many methodological issues by studying the relationship between use density and trip quality within (rather than among) individuals, Stewart and Cole (2001) showed that, for most people, evaluations of trip quality declined consistently—but not much—as use density increased. This suggests that, within reasonable bounds, the number of people encountered simply does not have a profound

effect on the quality of most people's experiences. This does not mean that managers should not manage for low-density settings in wilderness; rather it suggests that doing so may not profoundly improve experience quality for many visitors. Other attributes, such as visitor behavior, might be much more influential.

The number of people encountered in wilderness is seldom considered more than a minor problem, even though people often encounter more people than they prefer or consider acceptable. Instead, litter and evidence of inappropriate behavior—in terms of both physical evidence of use and user behavior—usually top the list of visitor concerns (Stankey and Schreyer 1987). Many of the primary influences on trip quality—both positive and negative—are either outside the control of managers or do not require more than avoiding actions that compromise the undeveloped and apparently natural wilderness setting. In several heavily used wilderness destinations in Oregon and Washington, the positive influences most often mentioned by interviewees were scenery, natural features, and the feeling of escape, peace, and quiet, while weather, bugs, and fatigue were common negative influences (Hall et al. 2007). Crowding and rude or inappropriate visitor behavior, the most commonly mentioned negative influence, was mentioned by only 26% of interviewees, despite heavy use of these destinations.

Few studies have assessed the effect of attributes on what people actually experience. In a study of visitors to an Arctic national park, Watson et al. (2007) found that encounters with others, the extent of developments, and the quality of preplanning information each affected three of five prominent dimensions of visitor experience. In Oregon and Washington wilderness, use density affected the degree to which privacy was experienced but neither the functions of privacy—release or personal growth (Cole and Hall 2008a)—nor the restorative components of wilderness. When comparing the experiences of visitors across wilderness with different levels of use, only 7 of 72 descriptors varied with amount of use (Cole and Hall 2008b). Further, in interviews conducted in three wilderness locations, experiences varied more among locations than with amount of use (Hall et al. 2007), suggesting that environmental attributes, largely outside managerial control, have more effect on experience than those attributes managers can control.

Stewardship of visitor experiences

Studies of the experiences people have in wilderness illustrate how rich and diverse these experiences are in terms of what people seek, perceive, and ultimately attain. In addition to being diverse and idiosyncratic, experience outcomes do not seem to be uniquely dependent on wilderness settings. Perhaps wilderness is just a particularly good place to have certain types of experience, and what is unique about the wilderness experience is a "bundle" of separate experiences, an "experience gestalt" that is dependent on a wilderness setting (Roggenbuck and Driver 2000) and can be most intensely attained in wilderness. In response to an open-ended question about what makes wilderness experiences different, visitors to wilderness in Washington and Oregon most frequently mentioned a combination of experiential and setting attributes: solitude, scenery, no impact, quiet, and challenge (Cole and Hall 2009).

Managers … can provide opportunities for solitude … but cannot ensure that visitors will find [it].

Although many attributes can affect experience quality, visitor experiences are typically affected most by attributes largely outside the control of managers. Moreover, managers can create only opportunities for experiences. They can provide opportunities for solitude, for example, but cannot ensure that visitors will find solitude. Many people are not seeking solitude, although many do find it desirable when it occurs. Some researchers have referred to this concept as "situated freedom" whereby managers structure the environment to some degree, setting boundaries on what can be experienced, but "within those boundaries recreationists are free to experience the world in highly individual, unique and variable ways" (Patterson et al. 1998, p. 430). Although crowding is perhaps the most serious threat to experiences subject to managerial control, it is seldom perceived by many people to be a substantial problem, even in the most heavily used places in wilderness. This seems to reflect the adaptability of humans. Most visitors plan, learn, and adjust their expectations; they rationalize and view things in relative terms. They prefer to use coping behaviors and decide for themselves whether or not to visit a crowded wilderness (Cole and Hall 2007). Given the diversity of wilderness visitors and visitor experiences, along with how adaptable visitors are to the conditions they find, managers attempting to protect experience quality cannot succeed without first deciding whom and what they are managing for. Should they manage for a high degree of solitude in wilderness even if solitude is not highly salient to most wilderness visitors, so visitors do not need to cope and rationalize? Should their efforts be focused on threats such as global climate change or invasive species? Answers to such questions go beyond the bounds of science, offering a glimpse of the questions to be resolved over the next 50 years.

References

Borrie, W. T., and R. M. Birzell. 2001. Approaches to measuring quality of the wilderness experience. Pages 29–38 *in* W. A. Freimund and D. N. Cole, compilers. Visitor use density and wilderness experience: Proceedings. 1–3 June 2000, Missoula, Montana. Proceedings RMRS-P-20. USDA Forest Service, Rocky Mountain Research Station, Ogden, Utah, USA.

Borrie, W. T., and J. R. Roggenbuck. 2001. The dynamic, emergent, and multi-phasic nature of on-site wilderness experiences. Journal of Leisure Research 33:202–228.

Brooks, J. J., G. N. Wallace, and D. R. Williams. 2006. Place as relationship partner: An alternative metaphor for understanding the quality of visitor experience in a backcountry setting. Leisure Sciences 28:331–349.

Bultena, G. L., and M. J. Taves. 1961. Changing wilderness images and forestry policy. Journal of Forestry 59:167–171.

Cole, D. N., and T. E. Hall. 2007. The "adaptable human" phenomenon: Implications for recreation management in high-use wilderness. Pages 126–131 *in* D. Harmon, editor. People, places, and parks: Proceedings of the 2007 George Wright Society Conference on Parks, Protected Areas, and Cultural Sites. George Wright Society, Hancock, Michigan, USA.

———. 2008a. Visitor experiences in wilderness: How they vary with amount of use and length of stay. Unpublished report. Aldo Leopold Wilderness Research Institute, Missoula, Montana, USA. Available at http://leopold.wilderness.net/unpublished/UNP124.pdf.

———. 2008b. Wilderness visitors, experiences, and management preferences: How they vary with use level and length of stay. Research Paper RMRS-RP-71. USDA Forest Service, Rocky Mountain Research Station, Fort Collins, Colorado, USA.

———. 2009. Perceived effects of setting attributes on visitor experiences in wilderness: Variation with situational context and visitor characteristics. Environmental Management 44:24–36.

Dawson, C. P., P. Newman, and A. Watson. 1998. Cognitive dimensions of recreational user experiences in wilderness: An exploratory study in Adirondack Wilderness Areas. Pages 257–260 *in* H. O. Vogelsong, compiler. Proceedings of the 1997 Northeastern Recreation Research Symposium. General Technical Report NE-241. USDA Forest Service, Northeastern Forest Experiment Station, Radnor, Pennsylvania, USA. Available at http://nrs.fs.fed.us/pubs/gtr/gtr_ne241/gtr_ne241_257.pdf.

Hall, T. E., B. J. Johnson, and D. N. Cole. 2007. Dimensions of wilderness experience: A qualitative investigation. Unpublished report. Aldo Leopold Wilderness Research Institute, Missoula, Montana. Available at http://leopold.wilderness.net/research/fprojects/docs7/qual_interview_rept_final.pdf.

Hammitt, W. E. 1982. Cognitive dimensions of wilderness solitude. Environment and Behavior 14:478–493.

Hockett, K., and T. Hall. 1998. Shenandoah National Park 1998 Backcountry and Wilderness Visitor Study. Unpublished report. Shenandoah National Park, Luray, Virginia, USA.

Lucas, R. C. 1964. The recreational capacity of the Quetico-Superior area. Research Paper LS-15. USDA Forest Service, Lake States Forest Experiment Station, St. Paul, Minnesota, USA.

Manning, R. E. 2011. Studies in outdoor recreation: Search and research for satisfaction. Third edition. Oregon State University Press, Corvallis, Oregon, USA.

Outdoor Recreation Resources Review Commission (ORRRC). 1962. Wilderness and recreation—A report on resources, values, and problems. ORRRC Study Report 3. Washington, D.C., USA.

Patterson, M. E., A. E. Watson, D. R. Williams, and J. R. Roggenbuck. 1998. An hermeneutic approach to studying the nature of wilderness experiences. Journal of Leisure Research 30(4):423–452.

Roggenbuck, J. R., and B. L. Driver. 2000. Benefits of nonfacilitated uses of wilderness. Pages 33–49 *in* S. F. McCool, D. N. Cole, W. T. Borrie, and J. O'Loughlin, compilers. Wilderness Science in a Time of Change Conference. Volume 3: Wilderness as a place for scientific inquiry. Proceedings RMRS-P-15-VOL-3. USDA Forest Service, Rocky Mountain Research Station, Fort Collins, Colorado, USA.

Schroeder, S. L., and I. E. Schneider. 2010. Wildland fire and the wilderness visitor experience. International Journal of Wilderness 16(1):20–25.

Stankey, G. H., and R. Schreyer. 1987. Attitudes toward wilderness and factors affecting visitor behavior. Pages 246–293 *in* R. C. Lucas, compiler. Proceedings: National Wilderness Research Conference: Issues, State-of-Knowledge, Future Directions. General Technical Report INT-220. USDA Forest Service, Intermountain Research Station, Ogden, Utah, USA.

Stewart, W. P., and D. N. Cole. 2001. Number of encounters and experience quality in Grand Canyon backcountry: Consistently negative and weak relationships. Journal of Leisure Research 33:106–120.

Watson, A., B. Glaspell, N. Christensen, P. Lachapelle, V. Sahanatien, and F. Gertsch. 2007. Giving voice to wildlands visitors: Selecting indicators to protect and sustain experiences in the eastern Arctic of Nunavut. Environmental Management 40:880–888.

About the author

David N. Cole *is a research geographer with the Aldo Leopold Wilderness Research Institute, Rocky Mountain Research Station, U.S. Forest Service, Missoula, Montana. He can be reached at (406) 542-4199 and dcole@fs.fed.us.*

SCIENCE FEATURE

Scientific study and enduring wilderness

By Kevin Hood

We must not only protect the wilderness from commercial exploitation. We must also see that we do not ourselves destroy its wilderness character in our own management programs. We must remember always that the essential quality of the wilderness is its wildness.

—Howard Zahniser (1953), principal author and champion of the 1964 Wilderness Act, U.S. Public Law 88-577

Abstract
This article examines three fundamental aspects of the Wilderness Act critical to wilderness managers and scientists seeking a common understanding as to how scientific study should occur in wilderness.

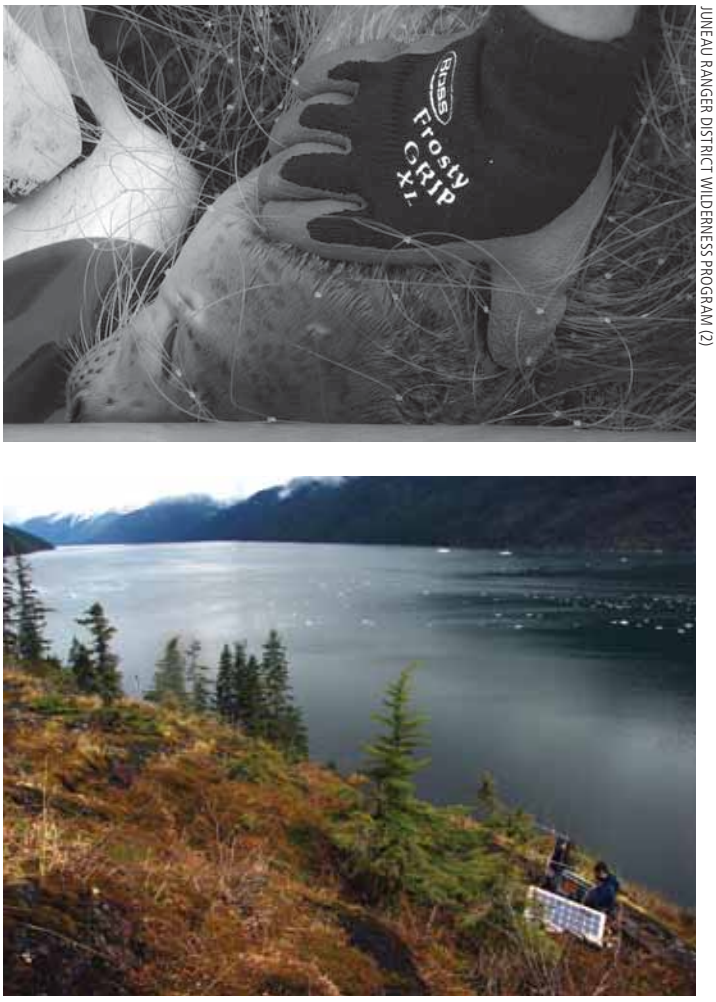
Key words
administration, management, monuments, science, untrammeled, wilderness, wildlife

HOWARD ZAHNISER CAUTIONED THAT WE MUST NOT ONLY protect wilderness but also guard against our own manipulative tendencies in administering these wild areas. Even scientific studies that advance our understanding of nature can compromise the integrity of wilderness (fig. 1). For example:

- A nationwide vegetation survey sought to grid the landscape with monument clusters consisting of stakes, nails, metal flashing, and rods and to access remote plots by helicopter (USDA Forest Service 2006).
- Wildlife researchers corralled molting Canada geese in net pens using aircraft, boats, and kayaks, anesthetized the birds, obtained blood and feather samples, and surgically implanted radio transmitters inside the abdomens of some (Hupp et al. 2010).
- A state agency tranquilized brown bears, extracted tooth and hair samples, and installed temporary radio collars and permanent ear tags (USDA Forest Service 2011).

These studies would expand knowledge of flora, fauna, and natural systems. They would be conducted by professionals with strong connections to their subject matter. Yet each was to occur in wilderness, where monumentation, installations, helicopters, and manipulation of wildlife are normally prohibited by the Wilderness Act.

Wilderness managers and scientists need to find a common approach whereby scientific activities adhere to Wilderness Act standards (fig. 2, next page) (Six et al. 2000; Bayless 1999; Eichelberger and Sattler 1994). Commendable efforts have been made toward this goal, notably, A Framework to Evaluate Proposals for Scientific Activities in Wilderness (Landres et al. 2010) and Wilderness Research in Alaska's National Parks (National Park Service n.d.). This article examines three fundamental aspects of



JUNEAU RANGER DISTRICT WILDERNESS PROGRAM (2)

Figure 1. Managers and scientists need to work together to ensure that scientific activities in wilderness do not compromise the essence of wildness, for example, (top) by trammeling wildlife or (bottom) by modifying remote lands with installations.

JUNEAU RANGER DISTRICT AND ADMIRALTY ISLAND NATIONAL MONUMENT WILDERNESS PROGRAMS (2)

Figure 2. Wildlife research methods that uphold the untrammeled quality of wilderness character include observing from afar how harbor seals react to vessel traffic (above, left), and using passive hair snares along game trails to obtain brown bear DNA samples (above).

the Wilderness Act whereby increased understanding may help wilderness managers and scientists improve collaboration.

1. The purpose of the Wilderness Act and the mandate to preserve wilderness character

The purpose of the Wilderness Act is to give present and future Americans the benefits of an enduring wilderness resource. The act distinguishes wilderness by powerfully expressing what it is and by explicitly noting what it is not. The law affirms qualities of wilderness using potent descriptors: untrammeled, undeveloped, natural, unimpaired, primeval, outstanding opportunities for solitude or a primitive and unconfined type of recreation. It lists wilderness purposes as recreational, scenic, scientific, educational, conservation, and historical use.

The Wilderness Act contrasts wilderness with other lands, asserting that wilderness areas are not occupied and modified by increasing population, expanding settlement, and growing mechanization; are not dominated by humans and their works; do not have permanent improvements or human habitation; and do not have a noticeable imprint of humans' work. The law checks uses that would degrade the natural environment. With narrow exceptions, it prohibits commercial enterprise, roads, motorized and mechanized use, as well as installations and structures.

Most pertinently, the act states that the paramount purpose of wilderness is to preserve wilderness character. Howard Zahniser selected "untrammeled" as the single word best embodying wilderness and he successfully fought to retain this unconventional term in the act's definition of wilderness (Scott 2002; Harvey 2005). It means uncontrolled, unimpeded, and unmanipulated and is a synonym for "unfettered." An interagency team charged with developing a strategy for upholding wilderness character selected "untrammeled" as one of the fundamental aspects, along with "undeveloped," "natural," and "outstanding opportunities for solitude or a primitive and unconfined type of recreation" (Landres et al. 2008). These qualities comprise wilderness character. By understanding that preserving wilderness character is the purpose of wilderness, and what this means, both scientists and managers will have a common basis for discussing what types of scientific activities are appropriate, or not, in wilderness (see "Using wilderness character to improve wilderness stewardship" by P. Landres, W. M. Vagias, and S. Stutzman, this issue, pages 44–48).

2. The role of scientific study in wilderness

The Wilderness Act recognizes scientific study as a valid wilderness purpose. But the law also asserts that the overarching purpose to which all other purposes are subordinate is preserving wilderness character. By affirming wilderness qualities and restraining degradative uses, the Wilderness Act sets high standards that ensure that scientific activities, as well as all other activities, do not compromise wilderness character.

Scientific studies should be designed to sustain the undeveloped and natural aspects of wilderness areas. They should not trammel wildlife, impinge upon outstanding opportunities for solitude, employ motorized equipment or mechanical transport, or place installations or structures. In wilderness, considerations of economy, expediency, and protocol yield to the primary purpose of upholding wilderness character, not to hinder research but to support and protect what wildness remains.

While the need to exercise restraint may challenge conventional protocol, it can be done. Wildlife research can be carried out in a manner that upholds the untrammeled aspect of wilderness (Schwartz et al. 2011). Examples include snaring hair, collecting

Considerations of economy, expediency, and protocol yield to the primary purpose of upholding wilderness character, not to hinder research but to support and protect what wildness remains.

feathers, sampling scat, and distantly observing populations or behavior (see fig. 2). Note that while the Wilderness Act provides limited exceptions for the use of installations and motorized equipment, the act makes no exception for trammeling wildlife.

Regarding the undeveloped quality, monumentation is a prohibited installation that degrades this aspect, even when it is deemed necessary and permitted. Strategies to avoid monumentation should be part of the planning process. Digital photos, global positioning system (GPS) waypoints, and detailed site maps will suffice in most cases. Similarly, helicopters are prohibited, degrade the undeveloped quality, and should be discouraged while traditional means of conveyance are encouraged.

The standards of the Wilderness Act apply unless they are expressly modified by another congressional law or, as discussed below, the act's own standard for certain exceptions are met. While these occasionally allow a scientific study to use methods that would typically be prohibited, the mandate to preserve wilderness character remains. That is, even if prohibited uses are authorized, the study still must strive to minimize impacts to wilderness character.

3. The restrictive allowance for exceptions

To emphasize the need for restraint, the Wilderness Act lists certain activities that are prohibited, including commercial enterprise, permanent and temporary roads, motor vehicles, motorized equipment, motorboats, aircraft landing, mechanical transport, and structures or installations. The act does, however, allow certain of these prohibited uses when they are "necessary to meet minimum requirements for the administration of the area for the purpose of this Act." The following questions help clarify if it might be legitimate to allow prohibited uses such as helicopters or monuments:

1. Is the study essential to preserve wilderness character?
2. Are the prohibited uses the minimum means necessary to conduct the study?
3. Will the research findings be integrated into the administration of the area?

The first question pertains to the necessity of the study and whether it upholds the purpose of the Wilderness Act. The second question concerns whether the proposed prohibited uses are genuinely the minimum that are necessary. The third question ensures that any exception granted is done so to improve the administration of the area as wilderness rather than allowing research for its own sake.

Only if all three questions are answered affirmatively and with compelling reasoning should a more comprehensive minimum requirements analysis be completed, such as provided at www.wilderness.net/MRDG/, to fully assess the legitimacy of employing the requested prohibited uses. Otherwise the proposed scientific study should be denied the prohibited uses.

This standard for exemptions solely concerns the prohibited uses in question; it is not a standard for approving the scientific study. Furthermore, scientists are not being singled out to adhere to the high standards required by the Wilderness Act: these standards apply equally to scientists, managers, and others.

Conclusion

There is no debate over whether or not research is a legitimate value and use of wilderness. The Wilderness Act specifically states that scientific purpose is a part of wilderness. But the law is also abundantly clear that the overarching purpose, the purpose to which all other purposes must yield, is that of preserving wilderness character. While temperance in support of this goal may challenge scientific orthodoxy, "there is nothing inherently incompatible between science and wilderness" (Landres et al. 2010).

Communication and education can help achieve the desired common approach. Scientists need to learn of the purpose of wilderness and high standards of the Wilderness Act. Managers need to understand what scientists seek to learn and what techniques they conventionally employ. Then, under this spirit of mutual understanding and collaboration, the two groups can work together to find progressive ways to conduct research that preserves or even replenishes wilderness character. For instance, scientists can remove monuments previously established as they convert to GPS and digital photography to record plots. They can report trash, monitor solitude, and carry out other tasks that help wilderness managers. Managers can provide knowledge of campsites and

access routes, offer logistical support, and possibly train their personnel to help with research.

Most importantly, conducting science appropriately in wilderness allows for the greater purpose of the Wilderness Act to be realized: the preservation of wilderness that affords us, as Howard Zahniser (1957) attests, profound knowledge vital to our well-being:

> We deeply need the humility to know ourselves as the dependent members of a great community of life, and this can indeed be one of the spiritual benefits of a wilderness experience. Without the gadgets, the inventions, the contrivances whereby men have seemed to establish among themselves an independence of nature, without these distractions, to know the wilderness is to know profound humility, to recognize one's littleness, to sense dependence and interdependence, indebtedness, and responsibility. Perhaps, indeed, this is the distinctive ministration of wilderness to modern man, the characteristic effect of an area which we most deeply need to provide for in our preservation programs.

Acknowledgments

I thank Jon Horn, Karen Dillman, Gwen Baluss, Tim Lydon, John Neary, and Peter Landres—all longtime U.S. Forest Service employees involved in wilderness management and research—who helped to shape my thoughts on this subject through many in-depth conversations. I also appreciate the constructive comments of several reviewers.

References

Bayless, J. 1999. Regulating National Park Service research and collecting: A fifty-year search for a legal, flexible, and standardized approach. Pages 418–422 *in* D. Harmon, editor. On the frontiers of conservation: Proceedings of the 10th Conference on Research and Resource Management in Parks and on Public Lands. The George Wright Society, Hancock, Michigan, USA.

Eichelberger, J., and A. Sattler. 1994. Conflict of values necessitates public lands research policy. Transactions of the American Geophysical Union 75:50–508.

Harvey, M. 2005. Wilderness forever: Howard Zahniser and the path to the Wilderness Act. University of Washington Press, Seattle, Washington, USA.

Hupp, J., J. Hodges, Jr., B. Conant, B. Meixell, and D. Goves. 2010. Winter distribution, movements, and annual survival of radiomarked Vancouver Canada geese in southeast Alaska. Journal of Wildlife Research 74(2):275.

Landres, P., C. Barns, J. G. Dennis, T. Devine, P. Geissler, C. S. McCasland, L. Merigliano, J. Seastrand, and R. Swain. 2008. Keeping It Wild: An interagency strategy to monitor trends in wilderness character across the National Wilderness Preservation System. General Technical Report RMRS-GTR-212. USDA Forest Service, Rocky Mountain Research Station, Fort Collins, Colorado, USA.

Landres, P., M. Fincher, L. Sharman, J. Alderson, C. Barns, T. Carlson, R. Anderson, S. Boudreau, D. Parsons, L. Boyers, and K. Hood. 2010. A framework to evaluate proposals for scientific activities in wilderness. General Technical Report RMRS-GTR-223WWW. USDA Forest Service, Rocky Mountain Research Station, Fort Collins, Colorado, USA.

National Park Service. n.d. Wilderness research in Alaska's national parks. Available at http://www.nps.gov/akso/Docs/Wilderness.pdf.

Schwartz, M., P. Landres, and D. Parsons. 2011. Wildlife scientists and wilderness managers finding common ground with noninvasive and nonintrusive sampling of wildlife. International Journal of Wilderness 17(1):5–7.

Scott, D. 2002. "Untrammeled," "wilderness character," and the challenges of wilderness preservation. Wild Earth 11(Fall/Winter):78.

Six, D., P. Alaback, R. Winfree, D. Snyder, and A. Hagele. 2000. Wilderness for science: Pros and cons of using wilderness areas for biological research. Proceedings RMRS-P-15. Volume 3, pp. 271–272. USDA Forest Service, Rocky Mountain Research Station, Fort Collins, Colorado, USA.

USDA Forest Service. 2006. Helicopter access to conduct forest inventory and analysis (FIA) in wilderness. Draft Environmental Impact Statement. Alaska Region, p. S8.

———. 2011. Analysis of ADFG proposal to perform research on brown bear home ranges and habitat usage in the Pack Creek Zoological Area located within the Kootznoowoo Wilderness. Minimum Requirements Decision Guide Worksheets. Admiralty Island National Monument, Tongass National Forest, Alaska, USA, p. 6.

U.S. Public Law 88-577. 3 September 1964. The Wilderness Act of 1964. 78 Stat. 890. Available at http://www.wilderness.net/NWPS/documents/publiclaws/88-577.pdf.

www.wilderness.net. n.d. Minimum Requirements Analysis Web page. Available at http://www.wilderness.net/ MRDG/.

Zahniser, H. 1953. New York's forest preserve and our American program for wilderness preservation. Public testimony to the New York State Joint Legislative Committee on Natural Resources. Pages 47–57 *in* E. Zahniser, editor. 1992. Where wilderness preservation began: Adirondack writings of Howard Zahniser. North Country Books, Utica, New York, USA.

———. 1957. The need for wilderness areas. The Living Wilderness 59 (Winter/Spring):48–53.

About the author

Kevin Hood *is the Alaska Region Wilderness Advisory Group representative and a special uses permit administrator with the U.S. Forest Service, Admiralty Island National Monument, Tongass National Forest, Alaska. He can be reached at (907) 789-6220 and kehood@fs.fed.us.*

SCIENCE FEATURE

The hidden consequences of fire suppression

By Carol Miller

Abstract

Wilderness managers need a way to quantify and monitor the effects of suppressing lightning-caused wildfires, which can alter natural fire regimes, vegetation, and habitat. Using computerized models of fire spread, weather, and fuels, it is now possible to quantify many of the hidden consequences of fire suppression. Case study watersheds in Yosemite and Sequoia–Kings Canyon National Parks were used to simulate where fires might have spread if they had not been suppressed, and what effects those fires would have had on fuels.

Key words

fire suppression, fire use, simulation modeling

EXCLUDING FIRE CAN HAVE DRAMATIC EFFECTS ON ECO-systems. Decades of fire suppression in national parks and other protected areas have altered natural fire regimes, vegetation, and wildlife habitat (Chang 1996; Keane et al. 2002). Suppressing lightning-ignited wildfires removes one of the most important natural processes from fire-dependent ecosystems, and runs counter to the untrammeled characteristics for which wilderness is to be managed. Many, if not most, lightning-ignited fires are suppressed in wilderness for myriad reasons and yet resource specialists have not had a good way to measure or monitor the effects of these management actions. What if we did not suppress these fires? Where would these fires have spread, and what would the effects have been? Can we quantify the impacts of suppressing these fires?

Recently, we asked these questions for two case study areas in the Sierra Nevada of California, both of which are almost entirely designated wilderness: the 74,057-acre (29,970 ha) South Fork of the Merced River watershed in Yosemite National Park and the 223,573-acre (90,480 ha) Upper Kaweah watershed in Sequoia–Kings Canyon National Parks. Yosemite and Sequoia–Kings Canyon National Parks have been leaders in the restoration of fire as a natural process. By 1970, both parks had instituted a policy whereby lightning-caused fires could be allowed to burn in certain areas. Despite these efforts, the parks continue to struggle with restoring natural fire regimes, and the majority of lightning-caused ignitions are suppressed for myriad biophysical and social reasons. For example, most of the South Fork of the Merced watershed has not burned since before the 1930s. This watershed contains the townsite of Wawona and the Mariposa grove of giant sequoia trees (*Sequoiadendron giganteum*), and fires are typically suppressed, which has led to unnaturally high fuel accumulations. In the Upper Kaweah watershed in Sequoia–Kings Canyon, about half of the lightning-caused ignitions are suppressed. The Upper Kaweah watershed contains most of the park's infrastructure and giant sequoia groves, and has a diversity of boundary interface issues. Because of the watershed's proximity to developed areas and topography that drains into the San Joaquin Valley, smoke and its impacts on air quality are a primary concern.

Models used

To quantify the impacts of suppression in these two study areas, a new retrospective modeling approach was developed (Davis et al. 2010) with an existing computer simulation tool called FARSITE (Fire ARea SImulaTor) (Finney 2004). FARSITE uses spatial information about topography and fuels, along with weather and wind data, to simulate the spread and behavior of wildland fire. FARSITE commonly supports fire incident management by using weather forecasts and projecting potential fire growth into the future (e.g., Finney and Ryan 1995), but in this case it was used to investigate where fires in the *past* might have spread. This retrospective application is particularly appealing because it avoids the uncertainty inherent in weather forecasts. When applied to past events, *actual* weather observations are used when running the model.

FARSITE was employed to simulate the spread and behavior of lightning-caused fires that were suppressed in the two study areas for an 11-year period (1994–2004). Suppressed lightning ignitions that occurred in this period were modeled chronologically, using actual weather conditions. The simulated spatial extent and severity of these modeled fires were used to update fuels data after each simulation year. Burn severity was defined according to the degree of fuel consumption that would be seen from a remotely sensed (aerial) perspective. This definition is compatible with Normalized Burn Ratio techniques of assessing fire severity (Key and Benson 2006; Thode 2005; Miller and Thode 2007) wherein remotely sensed imagery is used to assess the degree of change in vegetation before and after fire. The extent and severity of real fires that occurred during the study period were also included in the analysis, and fuels data were updated accordingly for any real fires that may have burned using burn severity data that were available (Thode 2005).

Park records indicate that 34 lightning ignitions in the South Fork of the Merced watershed and 71 lightning ignitions in the Upper Kaweah watershed were suppressed from 1994 to 2004. However, only ignitions with a significant potential for spread were considered. We omitted those that were detected and recorded in the fire occurrence database but that probably would never have spread from their ignition point because of fuel discontinuities, high fuel moistures, or subsequent weather conditions (e.g., rain). A combination of fire danger and fuel flammability was used to estimate each ignition's potential for spread; those with low potential were assumed to be "non-starters" and were ignored. For those lightning-caused ignitions with the potential for significant spread (10 in the South Fork of the Merced watershed and 32 in the Upper Kaweah watershed), FARSITE was employed to simulate fire spread and behavior. The actual hourly weather and wind observations from the time period during which the fire would have burned were used in the modeling.

The consumption of fuels by fire and the accumulation of fuel from year to year were simulated by way of a newly created dynamic model of fuel succession (Davis et al. 2009). This expert opinion–based fuel succession model was developed as part of the study in collaboration with scientists and managers from the parks and the U.S. Geological Survey (USGS). This deterministic model predicts how fuels can be expected to change over time. Fuels are represented by 1 of 22 fire behavior fuel models (Scott and Burgan 2005) that describe the available (burnable) portions of the vegetation (Scott and Burgan 2005). A fire behavior fuel model describes a fuel type in terms of how fire is expected to behave (Anderson 1982). For example, a conifer forest with a moderate load of dead and down woody fuel on the forest floor, represented as a Timber Litter 3 (TL3) fuel model, would be expected to have very low spread rates and flame lengths, whereas a forest represented by Timber Understory (TU5) with higher loads of surface fuel loads and a shrub understory would be expected to have higher spread rates and flame lengths. In the succession model, transitions from one fuel model to another and the rates of these transitions were based on expert knowledge of how vegetation would be expected to react to fires of low, moderate, and high burn severities and how quickly fuels accumulate in the associated vegetation types. Twenty-two diagrams were created to describe fuel succession for each of the fuel models present in the parks (table 1, fig. 1).

In a novel approach, FARSITE and the fuel succession model were used in tandem each year from 1994 to 2004, with FARSITE simulating where fires would have spread, and the fuel succession model updating fuels accordingly. In this way, fires simulated by FARSITE in one year could affect the spread and behavior of fires in subsequent years. By sequentially simulating fires for the 11-year period, a data set representing hypothetical pre-fire-season 2005 fuels was generated. This data set was compared with the actual landscape to quantify the cumulative effects of 11 years of suppression.

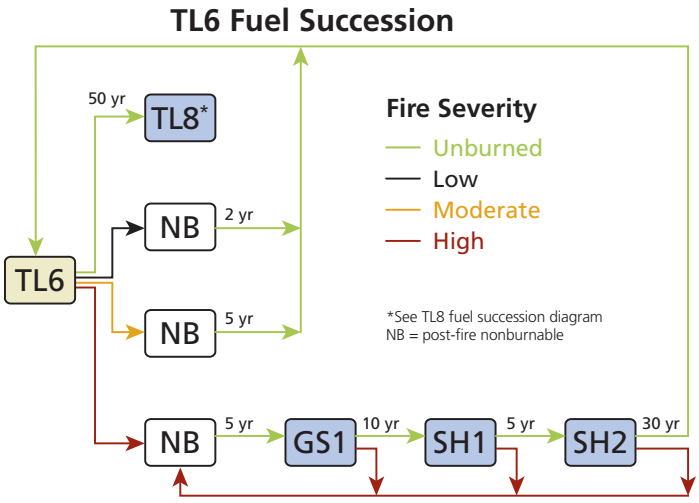


Figure 1. Sample diagram describing 1 of the 22 dynamic fuel succession models, this one for the Timber Litter 6 (TL6) fuel model. Depending on fire severity and time since fire, succession proceeds to other fuel types. See table 1 for fuel model descriptions.

One way these cumulative effects were quantified was with the Fire Return Interval Departure (FRID) index. This index quantifies the departure from the pre-Euro-American settlement fire return interval (Caprio et al. 2002; van Wagtendonk et al. 2002) and is computed as the time-since-last-fire divided by the characteristic fire return interval for the vegetation type. The characteristic fire return interval can be determined from published literature and fire history chronologies reconstructed from the tree rings of fire-scarred trees (Caprio and Lineback 2002). Through the use of Geographic Information System (GIS) software, FRID estimates have been spatially mapped and areas with the highest values of FRID or "ecological need" are typically prioritized for fuel management and restoration activities. The index is also useful as a coarse filter for measuring progress and setting maintenance priorities in ecological restoration; decreases in FRID values reflect improved ecosystem condition (Caprio and Graber 2000). Two FRID maps represented the end of the study time period, one for the simulated landscape and one for the actual landscape. By comparing the before and after maps of FRID, we were able to summarize the cumulative impacts of suppression on ecological condition during 1994–2004 (fig. 2) (Miller and Davis 2009).

Consequences of fire suppression

The impacts of suppression on fire return interval departure were surprisingly substantial, especially since they were accumulated

Table 1. Fuel models represented in Yosemite and Sequoia–Kings Canyon National Parks

Fire Behavior Fuel Model*	Description	Percentage of Watershed (1994 basis)	
		South Fork Merced	Upper Kaweah
Grass 1 (GR1)	Short, sparse dry climate grass	<0.1	<0.1
Grass 2 (GR2)	Low load, dry climate grass	0.2	1.4
Grass 4 (GR4)	Moderate load, dry climate grass	0.0	0.0
Grass-Shrub 1 (GS1)	Low load, dry climate grass-shrub	0.0	<0.1
Grass-Shrub 2 (GS2)	Moderate load, dry climate grass-shrub	<0.1	2.6
Shrub 1 (SH1)	Low load, dry climate shrub	0.0	0.0
Shrub 2 (SH2)	Moderate load, dry climate shrub	0.6	1.7
Shrub 5 (SH5)	High load, dry climate shrub	0.3	4.2
Shrub 7 (SH7)	Very high load, dry climate shrub	1.0	2.3
Timber Litter 1 (TL1)	Low load, compact conifer litter	3.5	6.6
Timber Litter 2 (TL2)	Low load, broadleaf litter	1.2	3.5
Timber Litter 3 (TL3)	Moderate load, conifer litter	19.0	8.9
Timber Litter 4 (TL4)	Small downed logs	10.1	10.4
Timber Litter 6 (TL6)	Moderate load, broadleaf litter	1.1	3.8
Timber Litter 7 (TL7)	Large downed logs	13.2	12.3
Timber Litter 8 (TL8)	Long needle litter	16.0	4.8
Timber Understory 1 (TU1)	Low load, dry climate timber-grass-shrub	3.3	2.3
Timber Understory 5 (TU5)	Very high load, dry climate timber-shrub	12.2	11.8
Nonburnable	N/A	18.3	23.3

**Source:* Scott and Burgan 2005.

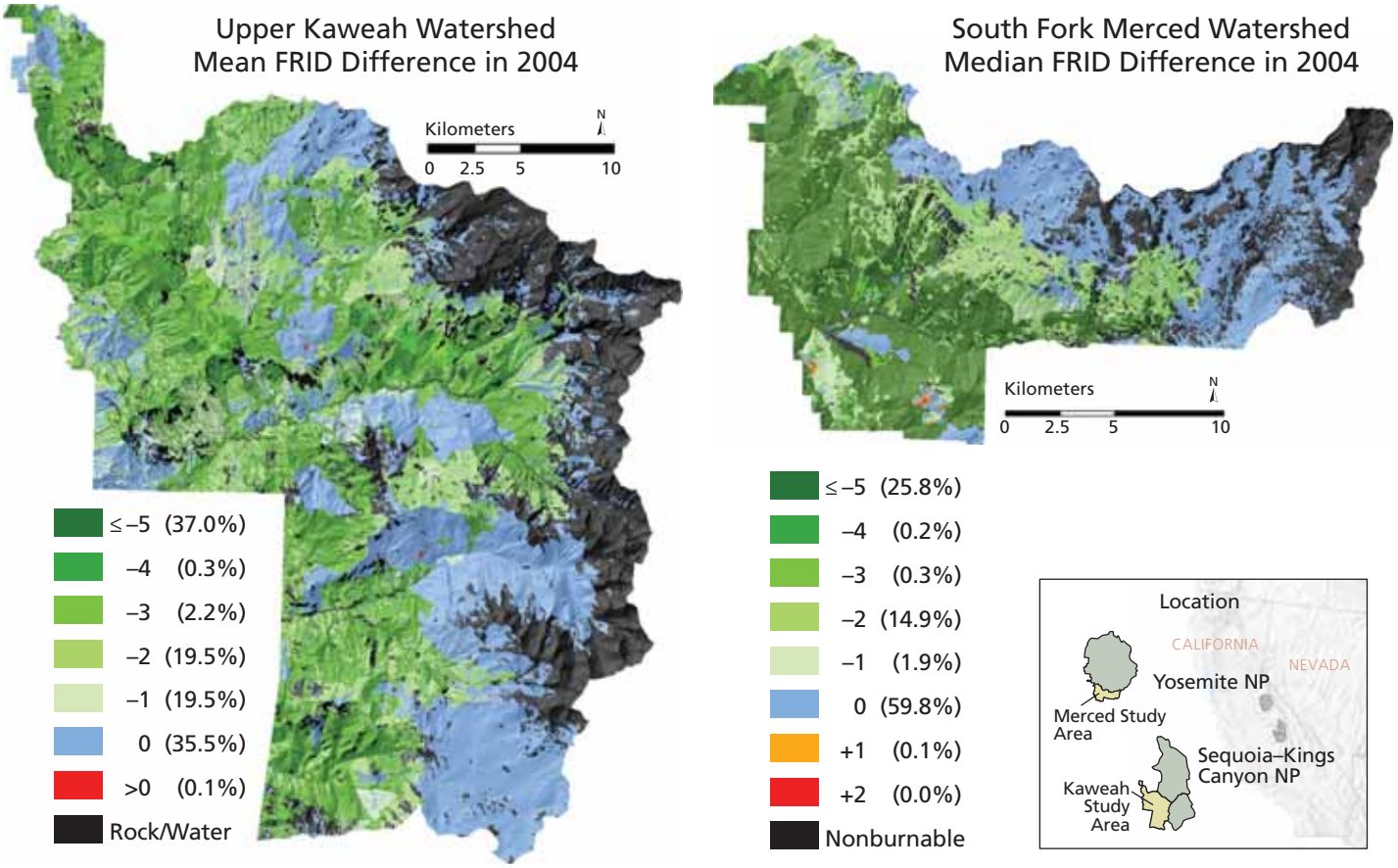


Figure 2. Difference in the Fire Return Interval Departure (FRID) index between the actual and modeled landscapes for the Upper Kaweah watershed and the South Fork of the Merced watershed. Negative values indicate that the modeled landscapes had lower FRID values (improved ecological conditions) than the actual landscapes.

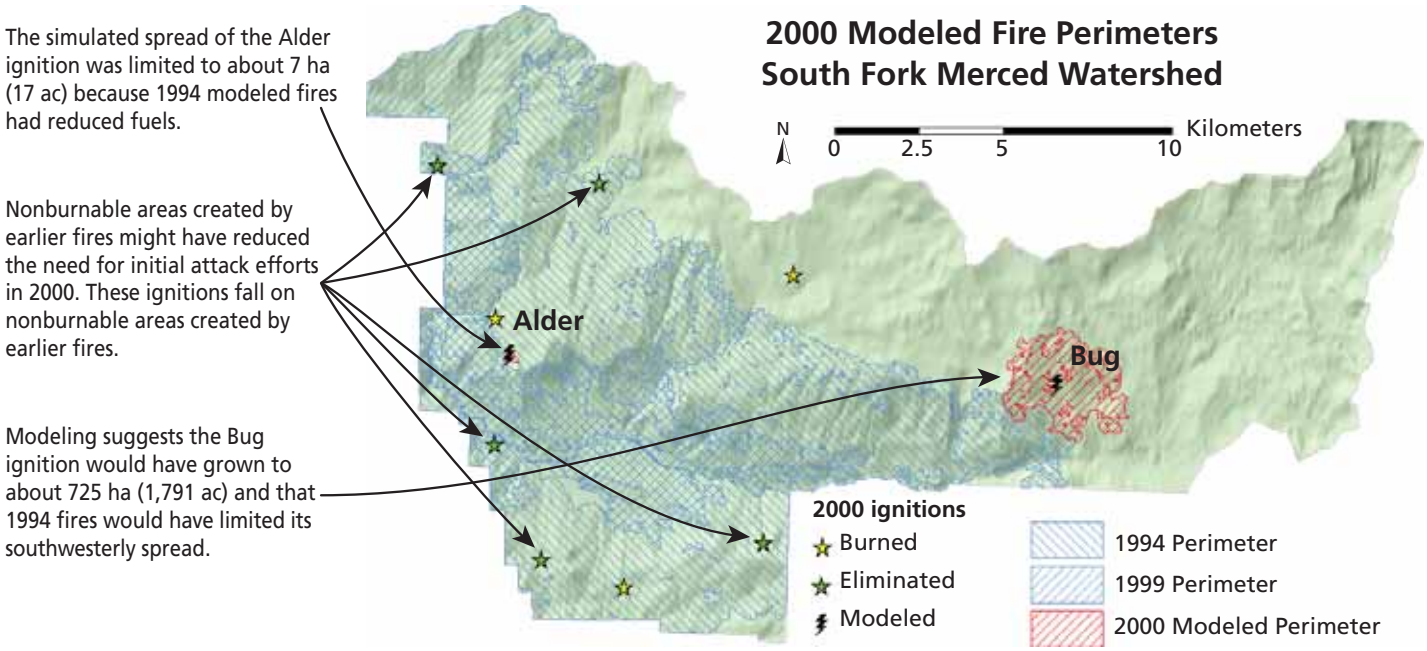


Figure 3. Analysis from the year 2000 for the South Fork of the Merced watershed illustrates how spread of fires was affected by fires simulated in previous years.

over a relatively short period of time (11 years). If all the ignitions simulated had been allowed to burn in the Upper Kaweah watershed in Sequoia–Kings Canyon, the average FRID would have improved from a value of 4.3 to a value of 0.3 (fig. 2). For the South Fork of the Merced watershed, the average FRID would have improved from the actual value of 4.5 (high departure) to a value of 1.8 (low departure) (fig. 2).

Simulations also showed that past fires have a major impact on how and where future fires burn. The simulations revealed a number of instances where the growth of fires would have been curtailed by burned areas if fires had not been suppressed, demonstrating how fires can create barriers to future wildfires in the form of fuel breaks (fig. 3). Fuel breaks can be helpful to managers when fighting future undesirable fires or when allowing desirable fires to burn. For example, knowing there is a fuel break in place between an ignition and a point of value such as a historical cabin might make managers more confident about making the decision to let an ignition burn.

The simulations illustrated yet another hidden consequence of suppression. Many ignitions may never have occurred because they were located in areas where an earlier modeled fire would have left little fuel remaining on the site. In the South Fork of the Merced study area, 5 of the 10 ignitions initially identified as having significant potential for spread were eliminated in this fashion.

Simulations … showed that past fires have a major impact on how and where future fires burn.… demonstrating how fires can create barriers to future wildfires in the form of fuel breaks.

In the Upper Kaweah study area, 9 were eliminated for this reason. This finding may resonate with many fire managers who have seen that lightning ignition patterns are not entirely random. Fire records include many examples where fires in the same general location are suppressed year after year.

The ignitions simulated in the South Fork of the Merced study area burned a total of 33,756 acres (13,661 ha; 43.5% of the watershed). In the Upper Kaweah study area, simulated fires burned a total of 137,793 acres (55,765 ha; 61.5% of the watershed) (table 2). Some of these fires were much larger than what would likely be acceptable to land managers or the public. For example, simulations suggest that approximately 20% of the South Fork of the

Table 2. Area burned in retrospective simulations of suppressed lightning-caused ignitions in the two case study watersheds

	South Fork Merced			Upper Kaweah		
	Number of Simulated	Area Burned		Number of Simulated	Area Burned	
Year	Ignitions	Acres	Hectares	Ignitions	Acres	Hectares
1994	3	15,327	6,203	2	1,164	471
1995	0	0	0	4	7,709	3,120
1996	0	0	0	1	1,040	421
1997	0	0	0	0	0	0
1998	0	0	0	1	27	11
1999	1	16,825	6,809	1	3,301	1,336
2000	1	1,604	649	0	0	0
2001	0	0	0	3	71,317	28,862
2002	0	0	0	2	1,762	713
2003	0	0	0	6	22,414	9,071
2004	0	0	0	3	29,056	11,759
Total	5	33,756	13,661	23	137,793	55,765

Merced watershed would have burned in 1994, another 20% just five years later in 1999, and some fires would have escaped the park boundary. In the Upper Kaweah, almost a third of the watershed would have burned in 2001. Although fires of this size are not unprecedented (Caprio 2004), in reality many of the modeled ignitions would have warranted management actions to confine them. Although confinement strategies were not considered in this study, a fruitful extension of these methods would be to apply more realistic "appropriate management response" scenarios and examine the effect on FRID.

Conclusions

The potential negative consequences of those fires that may have become quite large are extremely important and should be considered along with the potential positive consequences that might have occurred. However, these methods are not intended to second-guess suppression decisions. Suppression decisions are based on a complex suite of factors present at the time of ignition and are made without the privilege of hindsight or the certainty about weather conditions that exists after the fact.

Both parks are almost entirely wilderness and have fire management plans with extensive zones where the option of using natural ignitions to return fire to the landscape exists. Suppressing lightning-caused wildfires runs counter to the goal of protecting natural and untrammeled qualities in wilderness. Ideally, the decision to suppress or not to suppress a fire considers the possible consequences of allowing a fire to burn *as well as* the consequences of suppression. The research described here provides information about the consequences of suppression that could help inform decisions about future ignitions. Furthermore, knowledge of where nature would have treated an area with fire can help managers set priorities for fuel projects and, possibly, analyze opportunities for restoring "lost" ignitions with prescribed burns.

While parks and other protected areas strive to restore the natural role of fire and, in the case of wilderness, also protect untrammeled qualities, they must also protect a variety of other societal values, such as air quality and public safety. Retrospective analyses can also be applied to assess other consequences of suppression. The cumulative effects of suppression could be quantified in terms of smoke emissions over time or potential fire intensities. An understanding of what was gained and what was lost when each ignition was suppressed in the past is needed before managers can effectively communicate these trade-offs to the affected public and neighboring governmental entities. Further, this retrospective modeling approach is a quantitative method that park managers can use to better understand, measure, and track the cumulative effects of their decisions from year to year (Davis et al. 2010).

Ideally, the decision to suppress or not to suppress a fire considers the possible consequences of allowing a fire to burn* as well as *the consequences of suppression.

References

Anderson, H. E. 1982. Aids to determining fuel models for estimating fire behavior. General Technical Report INT-122. USDA Forest Service, Ogden, Utah, USA.

Caprio, A. C. 2004. Temporal and spatial dynamics of pre–Euro-American fire at a watershed scale, Sequoia and Kings Canyon National Parks. Association for Fire Ecology Miscellaneous Publication No. 2, pp. 107–125.

Caprio, A., C. Conover, M. Keifer, and P. Lineback. 2002. Fire management and GIS: A framework for identifying and prioritizing fire planning needs. Association for Fire Ecology Miscellaneous Publication 1:102–113.

Caprio, A. C., and D. M. Graber. 2000. Returning fire to the mountains: Can we successfully restore the ecological role of pre-Euroamerican fire regimes to the Sierra Nevada? Pages 233–241 *in* D. N. Cole, S. F. McCool, W. T. Borrie, and J. O'Loughlin, compilers. Wilderness Science in a Time of Change conference. Volume 5: Wilderness ecosystems, threats, and management. 23–27 May 1999, Missoula, Montana. Proceedings RMRS-P-15-VOL-5. USDA Forest Service, Ogden, Utah, USA.

Caprio, A. C., and P. Lineback. 2002. Pre–twentieth century fire history of Sequoia and Kings Canyon National Parks: A review and evaluation of our knowledge. Association for Fire Ecology Miscellaneous Publication 1:180–199.

Chang, C. 1996. Ecosystem responses to fire and variations in fire regimes. Pages 1071–1099 *in* Volume II: Assessments and scientific basis for management options, Sierra Nevada Ecosystem Project Final Report to Congress. Wildland Resources Center Report No. 37. Davis, California, USA.

Davis, B. H., J. van Wagtendonk, J. Beck, and K. van Wagtendonk. 2009. Modeling fuel succession. Fire Management Today 69(2):18–21.

Davis, B. H., C. Miller, and S. A. Parks. 2010. Retrospective fire modeling: Quantifying the impacts of fire suppression. General Technical Report RMRS-GTR-236WWW. USDA Forest Service, Fort Collins, Colorado, USA.

Finney, M. A. 2004. FARSITE: Fire Area Simulator–model development and evaluation. Research Paper RMRS-RP-4 Revised. USDA Forest Service, Ogden, Utah, USA.

Finney, M. A., and K. C. Ryan. 1995. Use of the FARSITE fire growth model for fire prediction in the US national parks. Pages 183–189 *in* J. D. Sullivan, J. Luc Wybo, and L. Buisson, editors. Proceedings of the International Emergency Management and Engineering Conference, May, Sofia Antipolis, France.

Keane, R. E., K. C. Ryan, T. T. Veblen, C. D. Allen, J. Logan, and B. Hawkes. 2002. Cascading effects of fire exclusion in the Rocky Mountain ecosystems: A literature review. General Technical Report RMRS-GTR-91. USDA Forest Service, Fort Collins, Colorado, USA.

Key, C. H., and N. C. Benson. 2006. Landscape assessment (LA). Pages LA-1–55 *in* D. C. Lutes, R. E. Keane, J. F. Caratti, C. H. Key, N. C. Benson, S. Sutherland, and L. Gangi, editors. FIREMON: Fire Effects Monitoring and Inventory System. General Technical Report RMRS-GTR-164-CD. USDA Forest Service, Ogden, Utah, USA.

Miller, C., and B. H. Davis. 2009. Quantifying the consequences of fire suppression in two California national parks. The George Wright Forum 26(1):76–88.

Miller, J. D., and A. E. Thode. 2007. Quantifying burn severity in a heterogeneous landscape with a relative version of the delta Normalized Burn Ratio (dNBR). Remote Sensing of Environment 109:66–80.

Scott, J. H., and R. E. Burgan. 2005. Standard fire behavior fuel models: A comprehensive set for use with Rothermel's surface fire spread model. General Technical Report RMRS-GTR-153. USDA Forest Service, Fort Collins, Colorado, USA.

Thode, A. E. 2005. Quantifying the fire regime attributes of severity and spatial complexity using field and imagery data. Dissertation. University of California, Davis, USA.

van Wagtendonk, J. W., K. A. van Wagtendonk, J. B. Meyer, and K. J. Paintner. 2002. The use of geographic information for fire management planning in Yosemite National Park. The George Wright Forum 19:19–39.

About the author

Carol Miller *is a research ecologist with the Aldo Leopold Wilderness Research Institute, USDA Forest Service Rocky Mountain Research Station, Missoula, Montana. She can be reached at (406) 542-4198 and cmiller04@fs.fed.us.*

CASE STUDY

Using acoustical data to manage for solitude in wilderness areas

By Jessica Briggs, Jessie Rinella, and Lelaina Marin

Abstract

The preservation of natural sounds and quiet is essential for protecting wilderness quality and character. Incorporating soundscape management into wilderness management plans is vital for maintaining the solitude and primitive character of wilderness areas. As development outside park areas increases, so does the potential of human-caused noise to impact wilderness areas within the parks. Lake Mead National Recreation Area is one of the first national parks to incorporate acoustical data into a wilderness management plan. Monitoring sites were set up in three wilderness areas over a two-year period to collect audio recordings, sound levels, and meteorological data. On-site listening was conducted to identify sound sources at the monitoring sites. Park personnel found that the monitored wilderness areas were quieter than other areas in the park, but there was still noticeable human-caused noise, primarily aircraft overflights. By including acoustical data in the wilderness management plan, the park has been able to reference the quietness of the wilderness areas while working with other agencies concerning potential noise-producing projects adjacent to park wilderness. The baseline data collected in the wilderness units will also assist in developing a soundscape management plan. A characterization of the natural acoustical environment will enable park management to improve overall ecosystem health and visitor experience by incorporating acoustical data into management plans and educating park visitors.

Key words

human-caused noise, Lake Mead National Recreation Area, natural sounds, soundscape, wilderness management plan

WILDERNESS PLAYS A SIGNIFICANT ROLE IN THE LIVES OF wildlife and people, whose activities in wilderness may benefit from its solitude and associated quiet. For example, sounds can have a profound effect on the perceived quality of an image or visual landscape (Benfield et al. 2010). Lake Mead National Recreation Area (NRA), particularly its nine designated wilderness areas, is home to many animals of special concern. Most animal species rely on a quiet environment for life-sustaining activities such as locating prey, finding mates, predator detection, and basic communication. Animals such as the Sonoran pronghorn (*Antilocapra americana sonoriensis*) avoid loud areas, which reduces their range and often fragments their habitat (Landon et al. 2003). Increased human activity is reducing suitable habitat for animals throughout the United States therefore it is important to preserve and protect wilderness resources.

Beyond providing habitat for wildlife, wilderness areas also contain many cultural resources and meanings important to people. The Spirit Mountain Wilderness in Nevada is significant and sacred to the Yuman-speaking tribes, used in ways according to their traditions. Modern sounds can have an impact on the traditional ceremonies and aesthetics of what is considered sacred land.

Lake Mead NRA, on the Nevada-Arizona border, comprises 607,028 ha (1,499,966 ac), including nine wilderness areas totaling approximately 75,187 ha (185,787 ac). Adjacent and potential wilderness-designated lands bring the total wilderness to more than 291,575 ha (720,482 ac) in size. Despite these designations, the western border of Lake Mead NRA lies only 9.7 km (6.0 mi) from Las Vegas, and its eastern boundary abuts Grand Canyon National Park.

Acoustical monitoring

To protect the acoustical environment of Lake Mead NRA wilderness, these areas first had to be characterized. Park personnel set up three acoustical monitoring sites in wilderness areas (LAME009, LAME010, and LAME011) between June 2007 and May 2009 to obtain baseline acoustical data (figs. 1 and 2, pages 82 and 83). Data from a nonwilderness control site (LAME007) were also included for comparison (see fig. 2). Monitoring equipment continuously collected readings of sound pressure level (intensity), recorded in decibels (dB), and frequency, or pitch, recorded in hertz (Hz). Audio recordings and meteorological data were collected, and each site was monitored for 30 days. On-site listening was also conducted to identify sound sources at each site. Sound levels are often adjusted, or "weighted," to match human hearing and are expressed as dBA. Existing ambient sound level, a median composite sound level of all sounds both natural and human-caused, was measured at each site in dBA. Natural ambient, an estimate of what the acoustical environment would be without the contribution of anthropogenic sounds, is also measured. However, only existing ambient is reported here.

NPS PHOTO

Figure 1. Technicians deployed acoustical monitoring equipment at Lake Mead National Recreation Area, this setup at site LAME009. The anemometer on the left is used to determine wind speeds. The microphone on the right is topped with a metal spike to prevent birds from landing on the foam windscreen. This equipment was used to document the extraordinary quiet of the wilderness areas at Lake Mead.

All three wilderness sites had median existing ambient levels lower than that of the nonwilderness site. For reference, 10 dBA is typical of a human breathing at 3 m (9.8 ft), 20 dBA is the volume of a human whispering at 5 m (16.4 ft), 35 dBA is a quiet residential area at night, and 60 dBA is conversational speech at 5 m (16.4 ft). Due to its proximity to Las Vegas, LAME009 was the loudest wilderness site, with a daytime existing ambient level of 30.7 dBA. LAME010 and LAME011 had daytime existing ambient levels of 13.4 dBA and 16.2 dBA, respectively. The two latter sites were found to be quieter than other sites at Lake Mead NRA. During the early morning hours, the sound levels recorded were extraordinarily low and often approached the equipment noise floor. The nonwilderness site, LAME007, was the loudest site, with a daytime existing ambient level of 33.5 dBA during the day (fig. 3).

Discussion

The quiet documented at Lake Mead NRA has become exceedingly rare as the world continues to get louder. As the U.S. population increases, so do transportation networks and development (U.S. Federal Highway Administration 2008). Since the wilderness areas are the quietest places in the park, they are more susceptible to the intrusion of human-caused noise, which is still present throughout the day.

The main source of human-caused noise was flights over the park. Aircraft can be heard throughout the park during all daylight hours. As would be expected for any park near a metropolitan area, multiple commercial and private flights pass overhead each day. Even more noticeable are the helicopter overflights associated with scenic tours, offered from dawn to dusk, exposing visitors to the beauty of Lake Mead, Hoover Dam, and Grand Canyon. Previous monitoring efforts have recorded an estimated 15–20 helicopter overflights per hour at some locations. The impact of overflights on the acoustical environment is much more noticeable at LAME007 and LAME009 (fig. 3).

Lake Mead NRA is one of the first parks to incorporate acoustical data into a wilderness management plan. Although the acoustical data will not be used to set standards and thresholds in the plan, park personnel will be able to reference the quiet of the wilderness areas while working with other agencies trying to develop land adjacent to these. In addition, this will help the park maintain or work toward desired acoustical conditions and develop a soundscape management plan. The final wilderness management

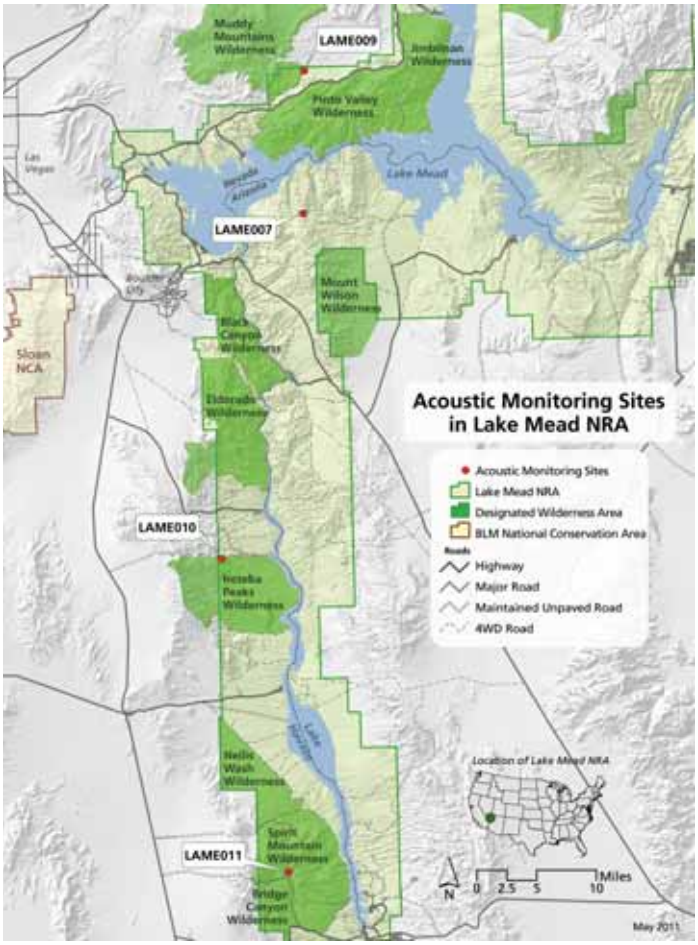


Figure 2. Locations of the three wilderness acoustical monitoring sites (LAME009, 010, 011) and the nonwilderness control site (LAME007) at Lake Mead National Recreation Area.

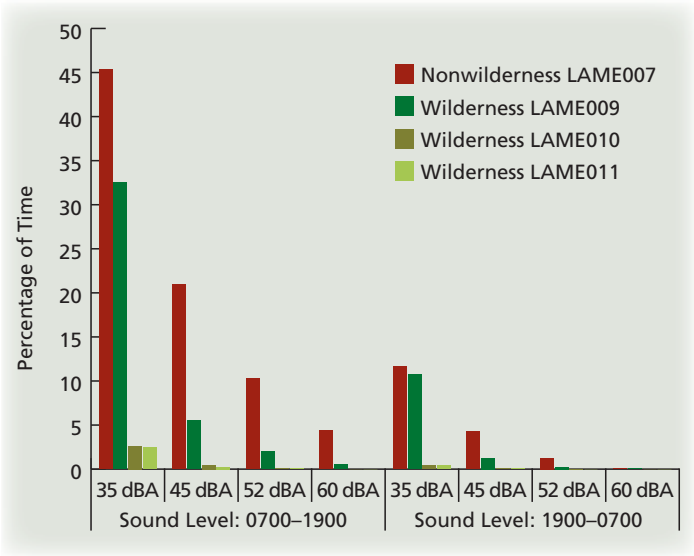


Figure 3. Percentage of time that measured sound levels were above four key thresholds: 35 dBA—this sound level causes an increase in blood pressure and heart rate in a sleeping human (Haralabidis et al. 2008), 45 dBA—the World Health Organization's recommendation for maximum noise levels inside bedrooms (Berglund et al. 1999), 52 dBA—the threshold for speech interference during park interpretive programs, and 60 dBA—the threshold for speech interruption for normal conversations (U.S. Environmental Protection Agency 1974).

plan draft may include more acoustical monitoring sites for a more robust description of the acoustical environment of wilderness at Lake Mead NRA.

Conclusion

Wilderness area management includes the protection of solitude and primitive character of these natural areas. Protecting the natural sounds and quiet is vital to maintaining the solitude and overall ecosystem health of wilderness areas. By incorporating acoustical data into a wilderness management plan, Lake Mead NRA will be able to work on protecting the solitude that wilderness areas are created to preserve.

References

Benfield, J. A., P. A. Bell, L. J. Troup, and N. C. Soderstrom. 2010. Aesthetic and affective effects of vocal and traffic noise on natural landscape assessment. Journal of Environmental Psychology 30:103–111.

Berglund, B., T. Lindvall, and D. H. Schwela, editors. 1999. Guidelines for community noise. World Health Organization, Geneva, Switzerland.

Haralabidis, A., K. Dimakopoulou, F. Vigna-Taglianti, M. Giampaolo, A. Borgini, A. M. Dudley, G. Pershagen, G. Bluhm, D. Houthuijs, W. Babisch, M. Velonakis, K. Katsouyanni, and L. Jarup. 2008. Acute effects of night-time noise exposure on blood pressure in populations living near airports. European Heart Journal 29:658–664.

Landon, D. M., P. R. Krausman, K. K. G. Koenen, and L. K. Harris. 2003. Pronghorn use of areas with varying sound pressure levels. Southwestern Naturalist 48:725–728.

U.S. Environmental Protection Agency (EPA). 1974. Information on levels of environmental noise requisite to protect public health and welfare with an adequate margin of safety. EPA, Washington, D.C.

About the authors

Jessica Briggs *(jessica_briggs@partner.nps.gov) is an acoustical technician with the NPS Natural Sounds and Night Skies Division in Fort Collins, Colorado.* ***Jessie Rinella*** *(jessie_rinella@nps.gov) is a physical science technician at Lake Mead National Recreation Area, Boulder City, Nevada.* ***Lelaina Marin*** *(lelaina_marin@nps.gov) is a resource management planner with the NPS Natural Sounds and Night Skies Division, also in Fort Collins.*

RESEARCH REPORT

Creating exploratory maps for wilderness impact surveys: Applications in campsite searches

By E. Tyson Cross, Paul Evangelista, Melinda Laituri, and Peter Newman

Abstract

Camping activities are known to damage vegetation, impede ecological processes, and negatively affect visitor experiences in wilderness areas. Understanding the spatial distribution of wilderness campsites prior to inventory, monitoring, and impact assessments can help direct land managers to minimize costs and use of limited resources. Spatial modeling can be used to create maps to predict the locations of recreational activities and their impacts. Models can be developed based either on a priori knowledge of campsite preferences or on field observations. In both cases the information can be related to environmental attributes (e.g., distance from trails) to predict where campsites are likely to occur. For this study campsite likeliness was predicted with two models: a Recreation Habitat Suitability Index (expert-based) and a Maximum Entropy model (statistics-based). Models tested in this study were selected because of their relative ease of use and potential contribution as a practical management instrument. Evaluations of model results using campsite occurrence coordinates suggested that the models performed equally well and therefore offer resource managers two options to prioritize and conduct impact inventories in wilderness areas. The model results reduced the area needed for campsite searches by at least one-third and highlighted areas of high probability. The resulting maps serve as a planning tool, helping to deploy inventory crews in an organized and efficient manner. These modeling techniques are promising instruments for a broad range of other recreation and wilderness character monitoring activities.

Key words

campsite monitoring, predictive models, recreation ecology, wilderness management

CONGRESSIONALLY DESIGNATED WILDERNESS AREAS

benefit from the highest level of protection of lands in the United States. As wilderness, land remains in its "natural" condition and is administered for the use and enjoyment of society in such a way that leaves it unimpaired for future generations (Wilderness Act 1964, section 2a). Though wilderness is protected from substantial development by humans, it is used for the primary purpose of "unconfined recreation" (Wilderness Act 1964). Unconfined recreation has led to a proliferation of ecological and social impacts from camping that have necessitated inventory, monitoring, and analysis efforts to understand and manage camping-related impacts (Cole 1993, 2004). Managing campsite impacts has both an ecological and a social significance. A review by Cole (2004) suggests that trampling associated with camping activities can affect soils and vegetation, damage or kill plants, compact mineral soils, and effectively displace organic soil horizons. Social impact studies have indicated that the presence of campsites in areas considered pristine (wilderness areas) can result in a "soiled" or "used" feel to an area (Leung and Marion 1999). Even camping-related impacts that are ecologically inconsequential, such as small pieces of litter, campfire rings, and small tree scars, can invoke negative symbolic meaning in the minds of wilderness visitors (Farrell et al. 2001).

Recognition of the ecological and social consequences related to campsite impacts has resulted in intensified inventory and monitoring efforts throughout the National Wilderness Preservation System (Cole 1993, 2004). While past inventories focused primarily on highly used areas, 21st-century management practices have trended toward inventory of entire wilderness areas (Cole 2004). The expansive area of potential wilderness camping makes it a challenge to travel efficiently to and locate campsites during the inventory process. Efficiency is increased when managers know beforehand where to target resources. Spatial models are a useful tool for resource managers, as they provide a cost-effective means to determine probability across large landscapes. Models are increasingly being used for early detection and to assess risk, develop management strategies, set priorities, and formulate policy (Lawson and Manning 2002; Van Wagtendonk 2003; Manning 2007). By integrating data and expertise with geographic information systems (GIS), models are used to map and predict probable campsite distributions.

This study examines two modeling approaches: (1) the Recreation Habitat Suitability Index (RHSI), an expert-based approach that uses a priori knowledge about campsite preferences, and (2) the Maximum Entropy model (Maxent), a statistics-based model that uses occurrence locations to predict conducive environmental conditions. Both models are relatively easy to employ and offer managers an applied planning tool to estimate the location of camping-related wilderness impacts. The tools presented in this study can be adapted to address a range of issues under a manager's purview, including invasive species management, solitude studies, and sensitive species monitoring efforts.

MAP BY TYSON CROSS. DATA FOR INDEX COLLECTED FROM USFS REGION 2 OFFICE.
BACKGROUND TOPOGRAPHIC MAP DATA COLLECTED FROM HTTP://SVINETFC4.FS.FED.US/CLEARINGHOUSE/INDEX.HTML.

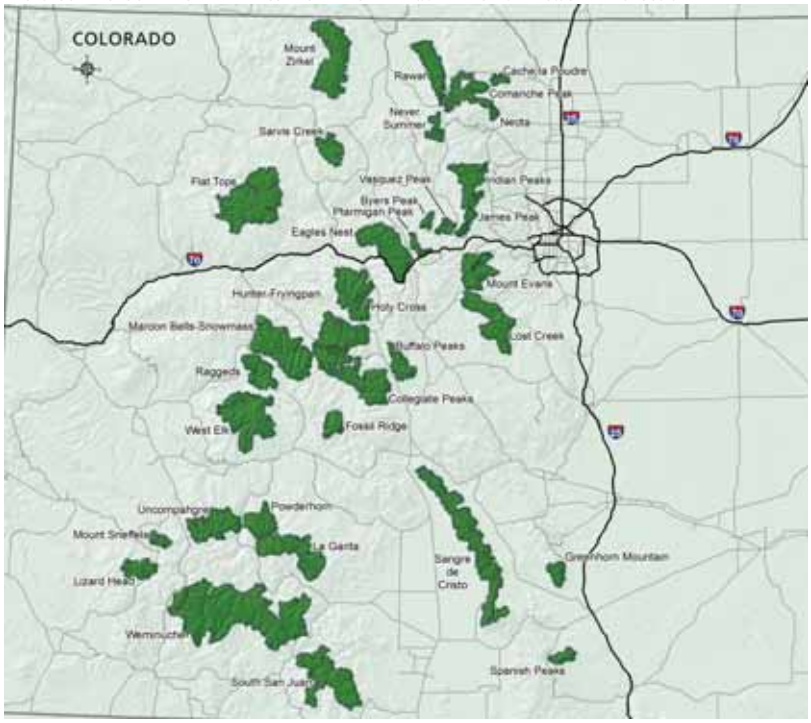


Figure 1. The study area includes 36 wilderness areas in Colorado. Scale: 1:3,000,000.

This method allows managers to visualize the areas requiring surveys, plan logistics for the search teams, and track inventory progress.

Methods

Study area and field data

The study was conducted in 36 federally designated wilderness areas in Colorado, generally located in the central and western parts of the state (fig. 1). These wilderness areas range in size from the 8,800-acre (3,564 ha) Byers Peak Wilderness to the 497,228-acre (201,377 ha) Weminuche Wilderness. In total the wilderness areas cover approximately 3.2 million acres (1.3 million ha). Study site ecosystem types vary from arid piñon-juniper woodlands of the Southwest to high alpine meadows in the central Rocky Mountains. Though the wilderness areas of Colorado are diverse, recreation in all of these areas is limited to primitive, nonmechanized activities with minimal facilities.

As part of an ongoing survey across Colorado, campsite location points were collected by independent field teams in the study area from 2004 to 2010. These points were used to develop the statistical model and to independently test both models. Location coordinates were acquired using Global Positioning Systems (GPS). A total of 2,607 campsites were recorded across the study area. A random selection of 30% (n = 782) of sites were set aside to test the two models; the remaining 70% (n = 1,825) were used to construct the Maxent model.

Recreation Habitat Suitability Index

Habitat Suitability Indexes (HSIs) are spatial models used by ecologists and wildlife biologists to map areas that organisms could potentially inhabit (Clark 1987; Larson et al. 2004). Originally, HSIs were developed to assist biologists with environmental impact assessments and in making daily decisions about managing wildlife, their distributions, and habitats. Clark (1987) adapted several wildlife habitat concepts to create a Recreation Habitat Suitability Index (RHSI). Similar to Habitat Suitability Indexes, RHSIs use a suite of predictor variables that are represented spatially, such as elevation, slope exposure, proximity to trail corridors, and proximity to water (Brunson and Shelby 1990). By integrating predictor variables with known recreational preferences, the RHSIs can predict probable areas of a given activity (e.g., wilderness camping).

In this study the RHSI is derived from expert knowledge, which determines the appropriate variables and how they should be weighted. A focus group consisting of wilderness program managers, lead wilderness rangers, and recreation ecologists examined the literature (Clark 1987; Brunson and Shelby 1990) and participated in development of the model (U.S. Forest Service, focus group discussions, personal communication, 18 September 2008). The RHSI was developed using the following algorithm:

$$\text{RHSI} = [0.2V_1 + 0.2V_2 + 0.35V_3 + 0.05V_4] + 0.2V_5$$

For this equation, distance to trails (V_1), streams (V_2), lakes (V_3), roads (V_4), and areas of low slope (V_5) was calculated using standard GIS methodology (ESRI ArcGIS v9.2). The variable V is a continuous score between 0 and 1, where 0 represents areas more than 800 m (875 yd) away from the variable and 1 represents areas directly adjacent to the variable. Variables are weighted based on the expected importance of the variable to camping. For example, because the focus group believes lakes are a more important predictor of campsite location than roads, this equation gives a higher weight to areas closer to lakes ($0.35V_3$) than to roads ($0.05V_4$). The modeled results are spatially displayed as a map using GIS, which shows the range of likeliness of a campsite between 0 and 1 (fig. 2).

Maxent model

The Maxent model uses location points to create a statistical model that can then be transferred to areas without data to predict where new location points are likely to be found. This tool was designed as a general-purpose predictive model that can be applied to incomplete data sets (Phillips et al. 2004; Phillips et al. 2006). Freely distributed on the Web (www.cs.princeton.edu/~schapire/maxent/) and fairly easy to use, Maxent operates on the principle of maximum entropy, making inferences from available data while avoiding unfounded constraints from the unknown (Phillips et al. 2006). Entropy can be described as a measure of uncertainty associated with a random variable; the greater the entropy, the greater the uncertainty. Adhering to these concepts, Maxent uses occurrence points (e.g., geographic coordinates of wilderness campsites) with multiple predictor variables (e.g., distance from trails) to model probability of occurrence. Predictions are presented as probability values from 0 to 1, with 1 being the highest likelihood. New applications of the Maxent model have demonstrated its wide utility in many subjects related to natural resource management (Evangelista et al. 2009; Evangelista et al. 2011).

To develop the Maxent model, a random selection of 70% of the campsite location data was used to train the model and the remaining 30% was retained for model evaluation. For comparison purposes with the RHSI model, the same environmental variables are used for both models. As with the RHSI, the modeled results are spatially displayed as a map using GIS.

Model evaluation

Evaluation of the model results was conducted by two statistical methods: the Area Under the receiver operating characteristic Curve (AUC) (Fielding and Bell 1997) and Cohen's Kappa (Cohen 1960). The AUC and Kappa values were calculated using Schroeder's ROC_AUC software (Schroeder 2006), developed specifically to assess modeling validity. The AUC measures the probability that a random positive point would fall outside the predictive range and the probability that a random negative would fall inside the predictive range. This measurement varies between 0 and 1. An AUC score of 0.5 indicates no better than random, while 1 is perfect discrimination. The Kappa statistic accounts for the probability of chance agreement between the model and the data, ranging from –1 to +1. The closer the Kappa statistic is to +1, the greater the agreement of the model.

Results

Both models were found to perform well when tested with the independent data. The AUC values for the RHSI and Maxent models were 0.92 and 0.93, respectively (table 1). Based on the definitions for AUC models by Hosmer and Lemeshow (2000), both models offered "outstanding" performance (>0.9). The Kappa values for RHSI and Maxent models were 0.66 and 0.72, respectively, both offering "good" performance based on Hosmer and Lemeshow (2000) (table 1). The RHSI predicted that the probable area for wilderness campsites was 979,661 acres (396,763 ha), while Maxent predicted that the probable area was 982,196 acres (397,789 ha) out of a total of 3,510,000 acres (1,421,550 ha).

Table 1. Performance of two models for campsite suitability

Model	AUC	Kappa
RHSI	0.92	0.66
Maxent	0.93	0.72

Note: The models were evaluated by Area Under Curve (AUC) and Cohen's maximized Kappa. All values are significant at $p<0.001$.

Discussion

The results of this study indicate that both RHSI and Maxent models are effective tools for wilderness management. When exploratory maps are displayed with topography (fig. 2), the resulting image provides managers with a planning tool for implementing efficient impact inventory efforts in wilderness. Using the methods presented by this study, search teams will focus on highly likely areas first and then move to surrounding areas of lower priority when sites are discovered in a given area, as opposed to gridding the wilderness or simply checking areas that appear to be good camping spots. When the maps are plotted, survey teams can track their progress by hashing out areas they have visited. In summary, this method allows managers to visualize the areas requiring surveys, plan logistics for the search teams, and track inventory progress.

MAP BY TYSON CROSS. DATA FOR INDEX COLLECTED FROM USFS REGION 2 OFFICE. BACKGROUND TOPOGRAPHIC MAP DATA COLLECTED FROM HTTP://SVINETFC4.FS.FED.US/CLEARINGHOUSE/INDEX.HTML.

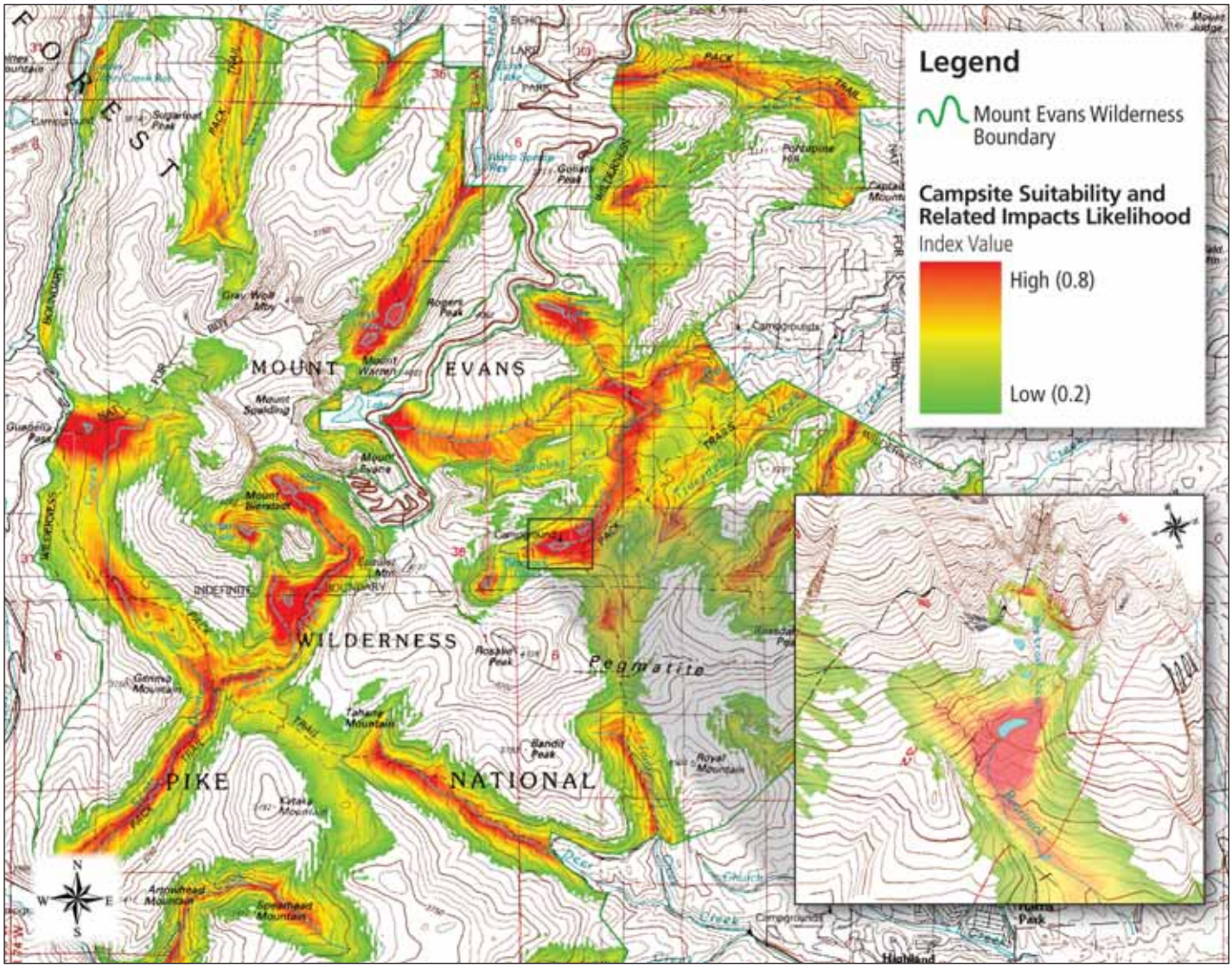


Figure 2. The map shows campsite suitability and the likelihood of camping impacts in the Mount Evans Wilderness, Colorado. Suitability ranges from 0 to 1, with 0 (green) being least likely and 1 (red) being most likely areas to find camping and related impacts. The inset map is a three-dimensional simulation that has been intentionally distorted to emphasize the way that the model interacts with environmental variables, such as slope, in Beartrack Creek drainage.

In addition to informing impact surveys, the models presented in this study can help management to create and standardize impact search protocols across districts and agencies, resulting in more cooperative and standardized data collection across management units. Furthermore, the modeling methods may be adapted for other priority wilderness management projects, such as solitude monitoring that highlights areas of the wilderness where one is least likely to have visitor encounters. Using these modeling techniques to create an exploratory encounters map, statistical surveys can be developed that prioritize areas least likely to encounter visitors while still monitoring areas with high likelihood of encounters. With these methods a wilderness manager may be able to create a better picture of the true Wilderness Recreation Opportunity Spectrum within the management unit, demonstrating the continuum of an area from low to high use (Cross 2010). Additionally, exploratory mapping techniques are frequently applied to invasive species inventories and may be useful to wilderness managers interested in mapping the potential distribution of invasive species prior to surveys (Evangelista et al. 2009).

This article introduces and validates two different methods for spatially modeling the same problem. The research concludes that

the Recreation Habitat Suitability Index offers a simple approach to guide campsite searches for resource managers who do not have access to field data of wilderness campsites, while Maxent offers a statistical modeling approach for managers who do have access to current and historical survey data. This is a key distinction, and the appropriate tool will depend on the extent of the data or local knowledge available.

References

Brunson, M. W., and B. Shelby. 1990. A hierarchy of campsite attributes in dispersed recreation settings. Leisure Sciences 12:197–209.

Clark, R. N. 1987. Recreation management: A question of integration. Western Wildlands 13:20–23.

Cohen, J. 1960. A coefficient of agreement for nominal scales. Educational and Psychological Measurement 41:37–46.

Cole, D. N. 1993. Campsites in three western wildernesses: Proliferation and changes in condition over 12 to 16 years. Research Paper INT-463. USDA Forest Service, Intermountain Research Station, Ogden, Utah, USA.

———. 2004. Environmental impacts of outdoor recreation in wildlands. Pages 107–116 *in* M. J. Manfredo, J. J. Vaske, B. L. Bruyere, D. R. Field, and P. J. Brown, editors. Society and natural resources: A summary of knowledge. Modern Litho, Jefferson City, Missouri, USA.

Cross, E. T. 2010. Comparing spatial modeling techniques for exploratory mapping: Applications in wilderness campsite searches. Thesis. Colorado State University, Fort Collins, Colorado, USA.

Evangelista, P. H., S. Kumar, T. J. Stohlgren, C. S. Jarnevish, A. W. Crall, J. B. Norman, and D. T. Barnett. 2008. Modeling invasion for a habitat generalist and specialist plant species. Diversity and Distributions 14:808–817.

Evangelista, P., T. J. Stohlgren, J. T. Morisette, and S. Kumar. 2009. Mapping invasive tamarisk (*Tamarix*): A comparison of single-scene and time-series analyses of remotely sensed data. Remote Sensing, Ecological Status and Change by Remote Sensing special issue 1:519–533.

Evangelista, P., S. Kumar, and T. Stohlgren. 2011. Assessing forest vulnerability and the potential distribution of three pine beetles under current and future climate scenarios in the Interior West of the U.S. Journal of Forest Ecology and Management 262:307–316.

Farrell, T., T. E. Hall, and D. D. White 2001. Wilderness campers' perception and evaluation of campsite impacts. Journal of Leisure Research 33(3):229–250.

Fielding, A. H., and J. F. Bell. 1997. A review of methods for the assessment of prediction errors in conservation presence/absence models. Environmental Conservation 24:38–39.

Hernandez, P., C. Graham, L. Master, and D. Albert. 2006. The effect of sample size and species characteristics on performance of different species distribution modeling methods. Ecography 29:773–785.

Hosmer, D. W., and S. Lemeshow. 2000. Applied logistic regression. Second edition. Wiley, New York, New York, USA.

Landis, J. R., and G. C. Koch. 1977. The measurement of observer agreement for categorical data. Biometrics 33:159–174.

Larson, M. A., F. R. Thompson III, J. J. Millspaugh, W. D. Dijak, and S. R. Shifley. 2004. Linking population viability, habitat suitability, and landscape simulation models for conservation planning. Ecological Modelling 180(1):103–118.

Lawson, S. R., and R. E. Manning. 2002. Tradeoffs among social, resource, and management attributes for the Denali wilderness experience: A contextual approach to normative research. Leisure Sciences 24:297–312.

Leung, Y. F., and J. L. Marion. 1999. Characterizing backcountry camping impacts in Great Smoky Mountains National Park, USA. Journal of Environmental Management 57:193–203.

Manning, R. 2007. Parks and carrying capacity: Commons without tragedy. Island Press, Washington, D.C., USA.

Phillips, S. J., M. Dudik, and R. E. Schapire. 2004. A maximum entropy approach to species distribution modeling. Pages 655–662 *in* Proceedings of the 21st International Conference on Machine Learning. ACM Press, New York, New York, USA.

Phillips, S. J., R. P. Anderson, and R. E. Schapire. 2006. Maximum entropy modeling of species geographic distributions. Ecological Modelling 190:231–259.

Schroeder, B. 2006. ROC/AUC-calculation. Available at http://brandenburg.geoecology.uni-potsdam.de/users/schroeder/download.html. Accessed 16 July 2010.

Van Wagtendonk, J. 2003. The wilderness simulation model: A historical perspective. International Journal of Wilderness 9(2):9–13.

Wilderness Act, 16 U.S.C. § 1 1 21 1964.

About the authors

E. Tyson Cross *is the Wilderness/Trails/Winter Recreation Program manager with the USDA Forest Service, Willamette National Forest, McKenzie River Ranger District, McKenzie Bridge, Oregon. He can be reached at etcross@fs.fed.us.* ***Paul Evangelista*** *is a research scientist in the Natural Resource Ecology Laboratory at Colorado State University, Fort Collins, Colorado.* ***Melinda Laituri*** *is an associate professor of geography with the Warner College of Natural Resources, Colorado State University, Fort Collins, Colorado.* ***Peter Newman*** *is an associate professor in the Department of Human Dimensions and associate dean of academic affairs in the Warner College of Natural Resources at Colorado State University, Fort Collins, Colorado.*

RESEARCH REPORT

Spiritual outcomes of wilderness experience: A synthesis of recent social science research

By Paul Heintzman

Abstract
This article synthesizes recent empirical research on wilderness experience and spirituality using the behavioral model of outdoor recreation. Antecedent conditions, setting, and recreation components together lead to short- and long-term spiritual outcomes. Implications for wilderness management are discussed.

Key words
spiritual outcomes, spirituality, wilderness experience, wilderness management

SPIRITUALITY IS OFTEN ASSOCIATED WITH WILDERNESS experience. Driver et al. (1996) suggested that a deeper understanding of the spiritual meanings that nature holds for humans could improve public land management. This article reviews 19 research studies, all but one published since 1997. In the vast majority of these studies, participants self-defined spirituality.

The behavioral model of outdoor recreation frames the empirical research reviewed and allows for the inclusion of many factors involved in the wilderness and spirituality relationship. The framework includes antecedent conditions, setting, and recreation components, which together lead to short- and long-term spiritual outcomes. This research synthesis may help park managers to better understand the processes that link wilderness experience with spiritual outcomes and to educate wilderness visitors about these processes (fig. 1).

Antecedent conditions

"Antecedent conditions" refers to people's characteristics prior to their wilderness experience. Personal history and current circumstances may influence wilderness experience. Examples include "baggage," such as fear (Fox 1999) and wilderness spiritual mentorship (Foster and Borrie *in press*). Spiritual mentorship refers to how parents, relatives, friends, guides, visual media, fiction, and nonfiction may influence a person's spiritual experience in wilderness.

People's motivations and attitude to engage in wilderness activity can be considered antecedents. Spiritual outcomes have been associated with visiting wilderness for spiritual journey and self-discovery (Riley and Hendee 2000). While some wilderness participants may not be seeking spiritual outcomes (Heintzman 2007; Stringer and McAvoy 1992), quantitative studies suggest that 46% to 69% of wilderness visitors seek or experience spiritual outcomes (Brayley and Fox 1998; Heintzman 2002, *in press*; Trainor and Norgaard 1999), although these outcomes may not be the most valued (Behan et al. 2001).

Sociodemographic characteristics are also considered antecedent conditions. For 514 campers at wilderness-class parks that are part of the Ontario Provincial Parks system in Canada, the degree to which introspection/spirituality added to satisfaction with the park experience was greater for males than for females and increased with education level (Heintzman *in press*). This gender difference was also true for day visitors to Ontario Parks (Heintzman 2002).

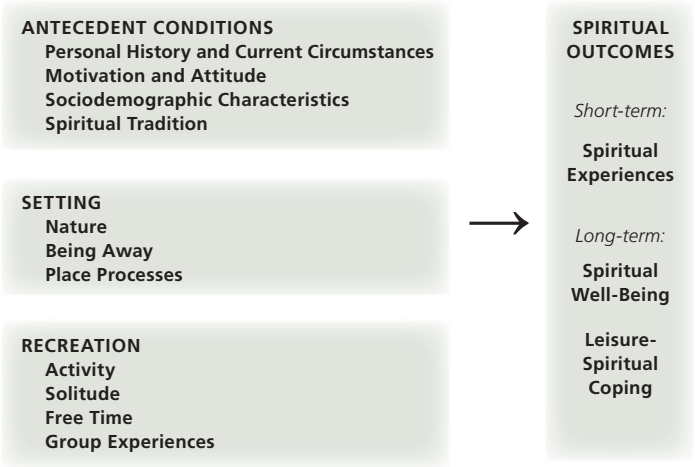


Figure 1. Wilderness experience and spirituality: The combination of the antecedent conditions a person brings to the wilderness experience, along with the setting and recreation components of the wilderness experience, may lead to spiritual outcomes of spiritual experience, spiritual well-being, and leisure-spiritual coping.

Finally, spiritual tradition should be considered. For example, for wilderness visitors with Christian understandings of spirituality, wilderness is viewed as God's creation, which is entwined with their spirituality (Foster and Borrie *in press*; Heintzman 2008).

Setting

Wilderness settings produce opportunities for spiritual outcomes for two main reasons. First, the natural setting of wilderness elicits a variety of outcomes, including a sense of wonder and awe (Fox 1997); connection with God or a higher power (Heintzman 2007, 2008); a sense of peacefulness, calm, stillness, and tranquility (Fox 1997; Heintzman 2007); therapeutic benefits (Fox 1997); and peak experiences that facilitate spiritual expression (McDonald et al. 2009). The biophysical characteristics of bona fide wilderness and direct contact with nature (Fredrickson and Anderson 1999), the natural backcountry setting (Marsh 2008), and naturalness (Riley and Hendee 2000; White and Hendee 2000) have all been associated with spirituality.

Second, being away appears to be as important as the natural setting for wilderness visitors. Stringer and McAvoy (1992) observed that greater opportunities for and enhancement of spiritual experiences in wilderness were usually ascribed to lack of constraints and responsibilities in wilderness compared with participants' everyday lives. Being away has been associated with the opportunity to get away from the everyday routine to focus on spirituality (Heintzman 2007, 2008); sacredness of life (McDonald et al. 2009); a simpler, less rushed life with no connection to the outside world, which enhances one's ability to "commune" with God (Bobilya et al. 2011); and escape from information technology (Foster and Borrie *in press*), all of which have been associated with spiritual outcomes. Being in nature may be important for some wilderness visitors and being away may be significant for others (Trainor and Norgaard 1999), but often the combination of these is conducive to spirituality (Foster and Borrie *in press*).

Place processes may be a third reason why wilderness settings produce opportunities for spiritual outcomes. The spiritually inspirational characteristics of wilderness have been linked to the phenomena of "place attachment" and "sacred space" as wilderness visitors have developed a sense of "at-homeness" and identification with the wilderness they visited (Fredrickson and Anderson 1999). Also, spiritual place meanings have been associated with sacred sites by visitors at the Apostle Islands (Salk et al. 2010).

Recreation

The type of wilderness recreation activity engaged in influences spirituality. While diverse wilderness activities have been associated with spirituality (Stringer and McAvoy 1992), Ontario Parks visitors, including visitors to wilderness parks, who spent most of their time at a park in more nature-oriented activities (e.g., viewing/photographing nature, guided hikes/walks) rated higher on the degree to which introspection/spirituality added to their satisfaction than did participants who spent most of their time in activities such as biking and swimming/wading (Heintzman 2002, *in press*). Similarly, Behan et al. (2001) found that spiritual benefits were valued more by foot travelers than by mountain bikers.

The intensity of a recreation activity in wilderness may also influence spirituality. The physical challenge of canoeing and hiking (Fredrickson and Anderson 1999), adventure, and mental and physical exercise (Marsh 2008) in wilderness have been associated with spirituality.

The type of spiritual outcome may also be influenced by the type of wilderness activity engaged in. Wilderness canoeists had spiritual experiences focused on interconnections with people while mountain hikers described spiritual experiences involving appreciation of wilderness beauty (Stringer and McAvoy 1992). Wilderness canoe paddling has also been found to offer an opportunity for spiritual reflection as it provides time to consider the difference between wilderness conditions and everyday life (Foster and Borrie *in press*).

Solitude in wilderness has led to peace, tranquility, a chance for an inner journey, time for self-reflection (Fox 1997), and renewal resulting from contemplation of life's deepest questions, which can be difficult or impossible during everyday life (Fredrickson and Anderson 1999). The importance of solitude for spirituality has also been reported by wilderness program participants (White and Hendee 2000), wilderness canoeists who participated in a solo experience (Heintzman 2007), and backcountry adventurers (Marsh 2008). Ontario Parks campers, including wilderness park campers, who visited the park alone rated introspection/spirituality higher than those who visited the park with others (Heintzman *in press*). In the case of group wilderness experiences, unscheduled time in wilderness when one is free to do as one chooses has been viewed as a critical component in spiritual experiences (Stringer and McAvoy 1992).

Group experiences, including the sharing of experiences, opinions, and ideas (Stringer and McAvoy 1992); working as a team (Fox 1997); "group trust and emotional support," "sharing common life changes," and a "non-competitive atmosphere" (Fredrickson and Anderson 1999); and the opportunity to discuss with others, to share stories and personal life experiences, and to have friendships and camaraderie (Heintzman 2007) have all been associated with spirituality. Conversations and discussions on one wilderness trip facilitated ongoing spiritual friendships (Heintzman 2008). Being part of a male-only or female-only group has also played an important role in spiritual outcomes (Fox 1997; Fredrickson and Anderson 1999; Heintzman 2008).

In some cases a balance of solitude and group experiences is helpful to spirituality (Heintzman 2007): "There is a dynamic of tension between interaction and solitude: Both enable a spiritual meaning" (Marsh 2008, p. 292).

Spiritual outcomes

The combination of antecedent conditions, setting, and recreation components may lead to spiritual outcomes. Spiritual experience in wilderness has been characterized by emotions of awe and wonderment at nature, feelings of connectedness, heightened senses, inner calm, joy, inner peace, inner happiness, and elatedness (Fox 1997); intense and often positive emotions (Stringer and McAvoy 1992); peacefulness, including peace with oneself and the world (Heintzman 2007); and religious-like or self-transcending feelings of peace and humility (Fredrickson and Anderson 1999). McDonald et al. (2009) discovered that participants' peak experiences in wilderness facilitated the sacredness of life, meaning and purpose, and transcendent "unseen" dimensions of spirituality.

Some studies suggest spiritual experiences in wilderness influence daily life. Fox (1999) claimed that feelings of empowerment, clarity, and inner peace led to inner strength and self-control, which affected both work life and family life by making participants feel more in control and stronger regarding relationships, roles, and personal goals. Stringer and McAvoy (1992) used post-trip interviews (i.e., 3–45 days after the trip) to conclude that wilderness experiences appeared to have some impact on participants' lives one month later. Just over half of the participants in McDonald et al.'s (2009) study observed that their wilderness peak experiences were significant in their life because the restorative elements of wilderness, such as the absence of distractions, human-made intrusions, and time constraints, along with solitude, provided time and space to think about meaning and purpose in relation to suffering, the limits of human life, and nonmaterial pleasures.

The impact on spiritual well-being for men on a wilderness canoe retreat 5–7 months later was associated primarily with the memory and recollection of the experience and less with specific behavioral change. Development and enhancement of spiritual friendships were the main impact on spiritual well-being 8–10 months after a different men's wilderness canoe trip (Heintzman 2008). Ninety percent of participants in a 20-day wilderness expedition believed the expedition had long-term value or life significance in terms of greater awareness of God, nature, and self (Daniel 2007). Eighty percent of 429 participants in a national study of wilderness experience reported a greater spiritual connection with nature as a result of their experience (Kellert 1998).

"Leisure-spiritual coping" refers to the ways that people receive help, in the context of their leisure, from spiritual resources (e.g., higher power, spiritual practices, faith community) during periods of life stress. Women who had experienced a major life change (e.g., deterioration of personal health, major career change, death of a loved one) found a wilderness trip provided the opportunity to leave everyday life stresses and experience spiritual rejuvenation (Fredrickson and Anderson 1999).

Conclusions

These research findings may be most beneficial to wilderness managers in terms of their understanding of the wilderness and spirituality relationship rather than their ability to provide specific guidance to bring about spiritual outcomes. Research indicates that the wilderness experience–and–spirituality relationship is multifaceted and complex. Thus, wilderness managers need to keep in mind this complexity and the components of the framework presented in this article. Managers should be aware of the important role that antecedent conditions play in wilderness spiritual outcomes, and that spiritual outcomes are associated with a wide range of wilderness recreation activities (e.g., Stringer and McAvoy 1992), but that certain activities (e.g., more nature-oriented activities) tend to be more associated with spirituality than are others (e.g., Heintzman 2002, *in press*).

To some extent research suggests that promoting spiritual outcomes amongst wilderness visitors may be related more to choices that visitors make than to management actions. However, wilderness managers, through educational programs and materials, can empower visitors who seek spiritual outcomes to make choices that will result in these types of outcomes.

In regard to setting characteristics, the following implications are particularly relevant in countries other than the United States that do not have wilderness legislation. First, given that nature and naturalness, as opposed to developed recreation areas, have been found to be associated with spiritual outcomes, the naturalness of wilderness needs to be upheld (Riley and Hendee 2000). Second, because being away in a different environment is important for spirituality, distractions and developments associated with civilization should be minimized. Third, given that spirituality tends to be associated more with nature-oriented activities (e.g., viewing/photographing nature) than with activities that are less focused on nature, providing opportunities for nature-based recreation is relevant. Fourth, since solitude in wilderness is important for spirituality (e.g., Heintzman *in press*), and visiting wilderness "to develop personal, spiritual values" is correlated with increased support for restrictions to ensure solitude (Cole and Hall 2006),

These research findings may be most beneficial to wilderness managers in terms of their understanding of the wilderness and spirituality relationship rather than their ability to provide specific guidance to bring about spiritual outcomes.

actions to maximize solitude are encouraged. Given these implications, wilderness management focused on maintaining solitude and naturalness, as the U.S. Wilderness Act of 1964 requires, along with inclusion of spiritual outcomes in classifications of wilderness benefits and in the use of limits of acceptable change (LAC) and similar planning frameworks, is recommended (White and Hendee 2000).

Some research suggests that a focus on an overall high quality of service rather than on specific management actions may be the best strategy to enhance spiritual outcomes (Heintzman 2002, *in press*). Nevertheless, as a significant positive relationship has been found between spirituality and participation in activities such as guided hikes, visiting historical/nature displays, visiting viewpoints/lookouts, and viewing/photographing nature (Heintzman 2002, *in press*), provision of nature interpretation and educational opportunities by wilderness managers may enhance spiritual outcomes. These interpretation and educational activities could also include facilitation of introspection for wilderness users (Brayley and Fox 1998).

References

Behan, J. R., M. T. Richards, and M. E. Lee. 2001. Effects of tour jeeps in a wildland setting on non-motorized recreationist benefits. Journal of Park and Recreation Administration 19(2):1–19.

Bobilya, A. J., L. D. Akey, and D. Mitchell, Jr. 2011. Outcomes of a spiritually focused wilderness orientation program. Journal of Experiential Education 33(4):301–322.

Brayley, R. E., and K. M. Fox. 1998. Introspection and spirituality in the backcountry recreation experience. Page 24 *in* M. D. Bialeschki and W. P. Stewart, editors. Abstracts from the 1998 Symposium on Leisure Research. National Recreation and Parks Association, Ashburn, Virginia, USA.

Cole, D. N., and T. E. Hall. 2006. Wilderness zoning: Should we purposely manage to different standards? Pages 33–38 *in* D. Harmon, editor. People, places, and parks: Proceedings of the 2005 George Wright Society Conference on Parks, Protected Areas, and Cultural Sites. The George Wright Society, Hancock, Michigan, USA.

Daniel, B. 2007. The life significance of a spiritually oriented, Outward Bound–type wilderness expedition. Journal of Experiential Education 29(3):386–389.

Driver, B. L., D. Dustin, T. Baltic, G. Elsner, and G. Peterson, editors. 1996. Nature and the human spirit: Toward an expanded land management ethic. Venture, State College, Pennsylvania, USA.

Foster, I. M., and W. T. Borrie. *In press*. A phenomenology of spiritual experiences in wilderness: Relating self, culture, and wilderness. *In* T. D. Wickham, editor. Proceedings of the 2011 Northeastern Recreation Research Symposium, 10–12 April 2011, Bolton Landing, New York. USDA Forest Service, Northern Research Station, Newton Square, Pennsylvania, USA.

Fox, R. 1999. Enhancing spiritual experience in adventure programs. Pages 455–461 *in* J. C. Miles and S. Priest, editors. Adventure programming. Venture, State College, Pennsylvania, USA.

Fox, R. J. 1997. Women, nature and spirituality: A qualitative study exploring women's wilderness experience. Pages 59–64 *in* D. Rowe and P. Brown, editors. Proceedings, ANZALS Conference 1997. Australian and New Zealand Association for Leisure Studies, and the Department of Leisure and Tourism Studies, The University of Newcastle, Newcastle, New South Wales, Australia.

Fredrickson, L. M., and D. H. Anderson. 1999. A qualitative exploration of the wilderness experience as a source of spiritual inspiration. Journal of Environmental Psychology 19:21–39.

Heintzman, P. 2002. The role of introspection and spirituality in the park experience of day visitors to Ontario Provincial Parks. Pages 992–1004 *in* S. Bondrup-Nielsen, N. W. P. Munro, G. Nelson, J. H. M. Willison, T. B. Herman, and P. Eagles, editors. Managing protected areas in a changing world. Science and Management of Protected Areas Association, Wolfville, Nova Scotia, Canada.

———. 2007. Men's wilderness experience and spirituality: A qualitative study. Pages 216–225 *in* R. Burns and K. Robinson, compilers. Proceedings of the 2006 Northeastern Recreation Research Symposium, 9–11 April 2006, Bolton Landing, New York. USDA Forest Service General Technical Report NRS-P-14. Northern Research Station, USDA Forest Service, Newton Square, Pennsylvania, USA.

CONTINUED ON PAGE 102 >>

RESEARCH REPORT

Remote sensing of heritage resources for research and management

By Alan P. Sullivan III, Kevin S. Magee, Philip B. Mink II, and Kathleen M. Forste

Figure 1. View of several hundred square kilometers of densely forested terrain along the eastern South Rim of Grand Canyon. Beneath this canopy are thousands of archaeological sites whose locations and characteristics are largely unknown to resource managers and scientists. This "hidden heritage" problem affects all units in the National Park System with significant human histories that are registered by highly variable concentrations of surface archaeological phenomena.

DRAPED LIKE EMERALD-GREEN BUNTING OVER THE NORTH-eastern corner of the Coconino Plateau in north-central Arizona, the ancient coniferous forest that mantles Grand Canyon National Park and the adjoining Kaibab National Forest (fig. 1) camouflages thousands of archaeological sites. Bypassed by millions of visitors annually are hundreds of square kilometers of de facto wilderness, terrain that is rarely seen or traversed by humans though not congressionally designated as wilderness. Yet the area's abundant hidden heritage creates a number of problems for resource managers and researchers alike. (Heritage resources are by-products of prehistoric and historic human activities such as ruins, hearths, and artifacts that are potentially significant to various cultural groups.) First, without accurate knowledge of the regional distribution of heritage resources, managers are constrained in their decision making, particularly in responding to "stressor" syndromes (e.g., population growth, resource extraction, encroaching development) that affect visitor experiences (Bishop et al. 2011). Second, critical ground-disturbing projects, often intended for public safety (e.g., road widening) or experience enhancement (e.g., visitor services expansion), are delayed or become needlessly intrusive because even coarse-grained data, such as the presence or absence of heritage resources, are chronically unavailable in considering alternative land-modification options (Ahlstrom et al. 1993). Third, scientific projects related to understanding the human and natural histories of parks and surrounding areas are disadvantaged because regional-scale information is discontinuous and the significance of known data points is incompletely understood because of erratic sampling (Sullivan et al. 2007).

Here, we share the results of recent applications of remote sensing that show great potential for helping managers and scientists overcome the aforementioned problems from two different information settings. In some cases, prior knowledge is available about the surface archaeology of heritage resources that may be affected by a surface-modifying project, yet the information required to

make an informed judgment regarding their disposition (e.g., preservation or long-term monitoring) is unavailable without additional, often expensive and time-consuming, archaeological excavation (Anderson and Neff 2011). Moreover, in most cases, no information is available whatsoever about the surface archaeology of heritage resources that may be threatened by park projects, visitor impacts, or operations of adjacent federal agencies (Fairley 2005). We intend to illustrate that remote sensing holds great promise in helping park managers—regardless of park size or annual number of visitors—meet their obligations within the letter and spirit of the Wilderness Act, as well as other federal heritage laws (e.g., National Historic Preservation Act). Our message is straightforward as well: current gaps in understanding the extent of the "hidden heritage" problem can be resolved with the broad and consistent application of the methods we discuss, which we believe ought to play a larger role in long-term management of and research planning for all units in the National Park System.[1]

Abstract
Resource managers are responsible for anticipating the likely locations and characteristics of heritage properties in order to plan effectively for ground-disturbing projects. In many cases selection of the most appropriate remedies or treatments for affected cultural resources must be made with either little advance notice or incomplete information. This research report describes how the application of remote sensing may be effectively integrated with wilderness research and management planning. For instance, magnetometry and ground-penetrating radar can rapidly acquire information (without excavation) about the size, depth, and distribution of anthropogenic features. Similarly, at the regional level, satellite images can be analyzed to achieve high rates of accuracy in the direct prediction of heritage resources in unsurveyed terrain. The decision-making implications of these applied remote-sensing studies are discussed with respect to allocating heritage-management funds for programmatic planning and cost-effectively acquiring cultural resource data from remote or inaccessible reaches of wilderness.

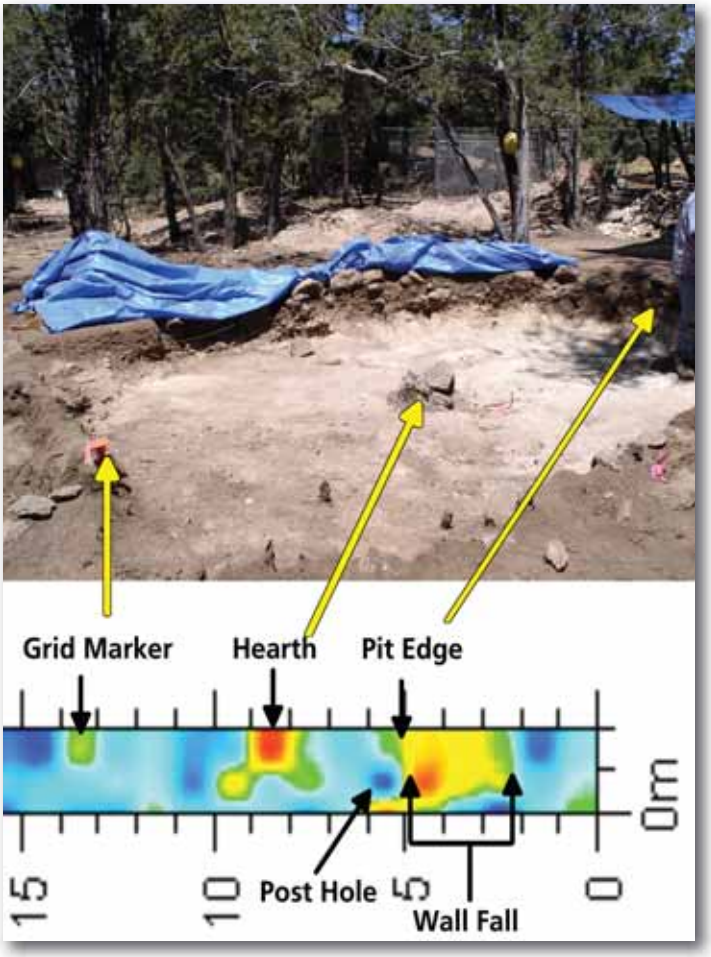
Key words
heritage resources, predictive models, terrestrial and satellite remote sensing

What's down there? Terrestrial remote sensing of known archaeological phenomena

Terrestrial remote sensing (TRS) consists of noninvasive techniques that measure variations in Earth's physical properties, such as subsurface voids, magnetism, and electrical conductivity (Kvamme 2008). Our explorations of the archaeological potential of TRS in Grand Canyon National Park focus on validating surface-subsurface feature relations and resolving ambiguous surface indications, as the following examples illustrate.

Site B:16:105 holds the remains of a prehistoric stone-outlined pit structure and a stone-outlined surface structure. Prior to excavation, a ground-penetrating radar (GPR) survey over the pit structure was conducted (in approximately two hours). The GPR unit, which is designed to detect and record anomalies that are registered by differences in travel times of radar waves beamed directly below the ground's surface (Conyers 2004), consists of a near-surface antenna and receiver that are systematically drawn across the vegetation-free surface of an archaeological site without touching it. In this case, results (fig. 2) clearly show the outline and depth of the pit structure as well as a large, deep, centrally located hearth. Upon excavation it was determined that this feature had deliberately been filled with rock at the time of abandonment, and therefore, in all likelihood, was "ritually" abandoned. This discovery is a first-time finding in the history of Grand Canyon archaeology for which, however, we now have a digital record to use in planning future excavations that are guided by GPR applications.

PHILIP B. MINK II



ALAN P. SULLIVAN III AND PHILIP B. MINK II

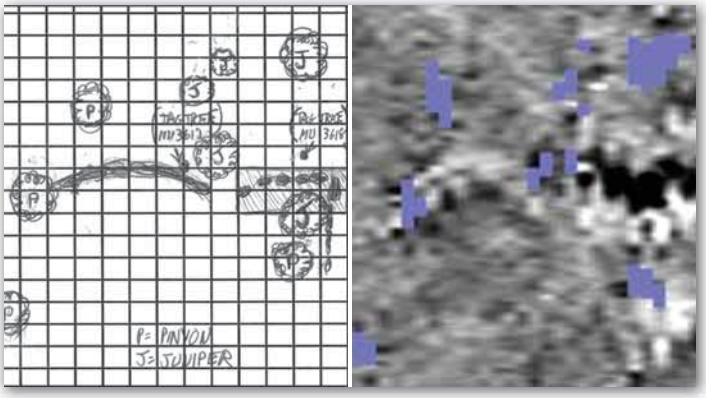


Figure 3. Field map (left) and corresponding magnetic gradiometer image (right) of anthropogenic features at site MU 3617, Grand Canyon National Park. The results of this study indicated that the rock alignment (curved element in left center, left image) was not an architectural feature, and the concentration of daub (fragments of a hardened mud surface that had once adhered to walls before their collapse) and rocks (lightly hatched area, right center, left image) was the remains of a heavily burned structure (dark tone at right center, right image). Trees and concentrations of impenetrable vegetation are represented by purple polygons.

KEVIN S. MAGEE

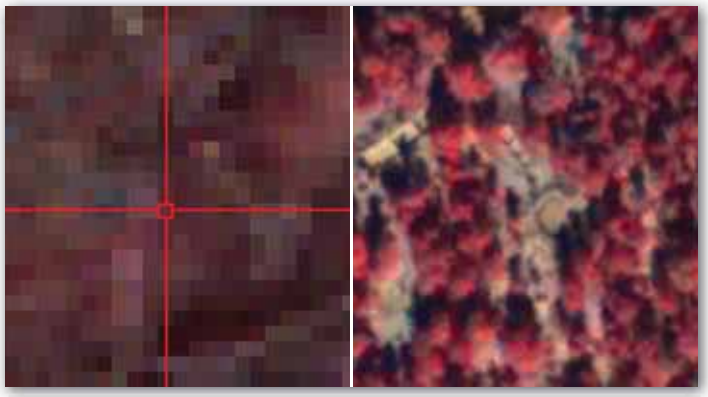


Figure 4. Tusayan Ruin in Grand Canyon National Park as it appears on a Landsat TM image (30 m [33 yd] pixels, left image) and a QuickBird image (1 m [3.3 ft] pixels, right image). Note that rooms, which appear as either individual quadrilateral spaces ("Kiva" in center, right image) or clusters of quadrilateral spaces ("Room Blocks" in left center and upper center, right image), can be distinguished from the tree canopy with QuickBird's fine-grained resolution.

In contrast, site MU 3617 is an amorphous scatter of prehistoric artifacts, daub fragments (pieces of dried mud that had been applied to formerly intact walls), and a linear rock alignment. To determine if the alignment was part of a buried structure and to explore the usefulness of another TRS method in a heavily vegetated area, a magnetic gradiometer (MG) survey was conducted over the entire site (in approximately four hours). MG measures variations in Earth's magnetic field that are attributable to anthropogenic activities (Aspinall et al. 2008). Results (fig. 3) strongly suggest that the rock alignment is unrelated to a buried structure and that the area where the daub was found appears to be the remains of a heavily burned structure. The significance of this finding is that burned sites, in contrast to unburned sites, have greater inferential potential because of the higher likelihood that they contain preserved carbonized remains.

TRS provides resource managers and researchers with nonintrusive methods for investigating the range of spatial patterning of buried and nonburied archaeological features. In addition, these culturally sensitive techniques provide nondestructive options for heritage managers who must assess the interpretive potential of sites and features that may be considered sacred by indigenous peoples. Conducting geophysical survey on sites slated for excavation for legal compliance purposes (as in the case of site B:16:105) provides a valuable set of baseline data that can inform future interpretations of sites that will not be excavated (as in the case of site MU 3617). Finally, the noninvasive nature of these techniques allows researchers to preserve sites while working to understand their significance within the larger regional context of park resources, whether they are associated with designated or de facto wilderness.

Figure 2 (left). Correspondence between anomalies revealed by ground-penetrating radar (lower) before excavation and features disclosed after excavation (upper) at site B:16:105, Grand Canyon National Park.

What's out there? Satellite remote sensing of unknown archaeological phenomena

Satellite remote sensing (SRS) employs sensors on spacecraft to capture variation in light reflectance and absorbance at different spatial (pixel size) and spectral (electromagnetic bandwidth) resolutions (Parcak 2009). High-resolution sensors, such as the one carried on the QuickBird satellite (0.6–2.4 m [2.0–7.9 ft]), are required to differentiate abundant small-scale archaeological phenomena from their natural surroundings (fig. 4).

Our recent applications of SRS, both pixel-based and object-oriented[2] studies, have focused on developing direct predictive models of archaeological phenomena in the Grand Canyon area (Sullivan et al. 2006). Simplifying greatly, this approach has

The noninvasive nature of these techniques allows researchers to preserve sites while working to understand their significance within the larger regional context of park resources, whether they are associated with designated or de facto wilderness.

KATHLEEN M. FORSTE AND KEVIN S. MAGEE

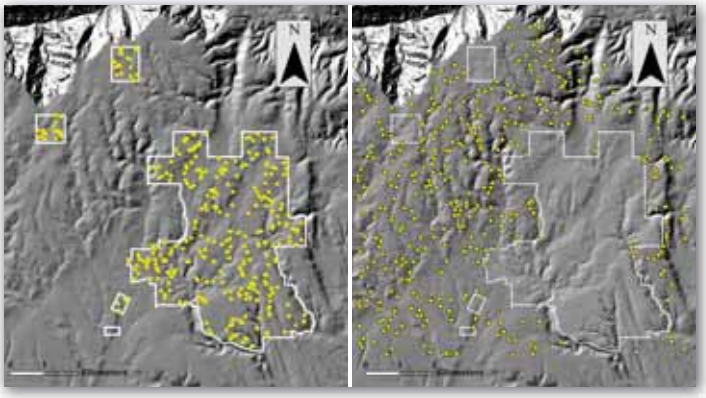


Figure 5. Geo-referenced and processed QuickBird satellite image showing the locations of known archaeological phenomena on the left (i.e., "training data" for the "fuzzy" classification component of the direct predictive model) and the predicted locations of previously unknown archaeological phenomena (right image) in an area south of Desert View, Grand Canyon National Park and Kaibab National Forest.

several steps. First, distinctive spectral signatures, which can be considered electromagnetic "fingerprints" of the pixels associated with different kinds of known archaeological phenomena, are extracted from geo-referenced satellite images. Next, these signatures are projected to the pixels and objects associated with unsurveyed terrain in the same images, a procedure that yields probability maps of the distribution of archaeological phenomena (Benz et al. 2004). Finally, model predictions are then checked for accuracy by intensive archaeological survey to ascertain the number of true positives (correct "presence" predictions), false positives (incorrect "presence" predictions), false negatives (incorrect "absence" predictions), and true negatives (correct "absence" predictions). Figure 5 graphically illustrates the output of such modeling for an area along the eastern South Rim of Grand Canyon National Park; each dot represents the predicted location of a heretofore unknown archaeological site. Even though verification of the model's accuracy is ongoing, provisional results indicate that the overall distribution of archaeological phenomena provides an empirically grounded basis for management planning at the regional level, especially with regard to where sites are clustered versus where they are not.

Another application was focused on predicting the presence of masonry structures, which are often obscured by vegetation that has recolonized long-abandoned ruins, from the attributes of their associated artifact scatters, which are commonly vegetation-free. The initial hypothesis was that the vegetationally unobscured scatters would register the highest contrast with the natural background because of unrestricted line of sight between the target (artifact scatter) and the satellite-borne sensors. Using several statistical satellite-image transformation and enhancement techniques and "fuzzy" classification procedures,[3] we discovered, however, that the highest percentages (around 80%) of true positives were achieved for partially obscured scatters. These results suggest that the most sensor-distinguishable signal may occur at the interface between archaeological remains and the forest margin, a finding that dramatically expands the range of application of SRS in densely forested ecosystems. Thus managers and scientists have greater latitude to evaluate alternatives of a proposed project that are likely to encounter archaeological sites and, more importantly, select the option that enhances preservation of the greatest number of cultural resources.

Implications and future directions

Of the many challenges that confront heritage resource managers, from short-term compliance to long-term planning, all are unified by the same issue that scientists face: access to reliable data upon which informed decisions can be made. Our central theme has been to illustrate the advantages of routinely incorporating TRS and SRS in any park endeavor to create information-rich digital databases. Actually, training in TRS has been a National Park Service priority, yet its application is spotty, which is largely attributable to the widespread lack of equipment and processing software. Nonetheless, TRS, like geographic information systems and global positioning systems, can no longer be considered technological gimmickry with limited applications but, instead, should be elevated to the status of integral tools of management practice and scientific method (Mink et al. 2006). In contrast, SRS applications in archaeology have barely advanced beyond the proof-of-concept stage; our modeling studies suggest, however, that the upside planning potential of SRS-based regional predic-

tive models is considerable yet untapped. Unquestionably, the widespread availability of TRS and SRS images of different kinds of archaeological phenomena can be integrated seamlessly into planning because both managers and scientists need to be able to predict what is "down there" or "out there" with certain degrees of confidence.

Acknowledgments

We thank the C. P. Taft Research Center (University of Cincinnati), the National Geographic Society/Waitt Grants Program, and the NPS National Center for Preservation Technology and Training for materially supporting our predictive modeling studies. Geophysical equipment was purchased by the University of Kentucky with a National Science Foundation Major Research Instrumentation Grant (#0619464). We thank Jan Balsom and the staff of the Science Center at Grand Canyon National Park and John Hanson (now retired), Neil Weintraub, and Tom Mutz of Kaibab National Forest for intellectual and administrative support of our research. Comments from several reviewers improved this report's organization and content.

Notes

1. For the two TRS methods discussed in this report, ground-penetrating radar and magnetic gradiometry, contracting expenses vary from $959 to $906 daily, respectively, for initial equipment setup and instrumentation calibration, and $859 to $806 per day thereafter. These estimates include costs of machine time, personnel, and software but do not include travel, report write-up, and institutional overhead. Considering that the purchase price for a magnetic gradiometer is about $20,000 and a ground-penetrating radar system is about $20,000–$50,000, depending on the number and sensitivity of the antennas selected, many smaller units of the National Park System may opt to partner with universities or other agencies whose large capital equipment budgets have enabled the acquisition of such devices.

Table 1 contains basic information about satellite image acquisition and processing costs. In many cases, special licensing "network" arrangements can be negotiated with software providers and, depending on location, scene size, and the image "tasking" problem, special federal pricing may be available as well.

When the costs of excavation, including perpetual curation of recovered materials, and the costs of time-consuming survey to cover large areas are compared with the estimates in table 1, what seem like significant upfront capital investments for either TRS or SRS are reasonably cost-effective (not unlike the start-up and maintenance expenses of any national park unit–specific GIS).

Table 1. Basic costs of satellite image acquisition and processing

Satellite Imagery	*Spatial Resolution*	*Cost for 100 sq km (39 sq mi) (archived)*	*Cost for 100 sq km (39 sq mi) (tasked)*
4 band[1]	0.5 m–4.0 m (1.6 ft–13.1 ft)	$1,000–$1,400	$2,000–$6,000
8 band[2]	0.5 m–2 m (1.6 ft–6.6 ft)	$2,900	$3,800–$7,800
Software			
Pixel-based	$750–$1,250[3]		
Object-based	$16,704[4]		
Labor			
2 weeks' labor for imagery scientist	$3,600		
Total Cost			
Minimum	$1,750		
Maximum	$24,504		

[1]IKONOS, QuickBird, GeoEye-1 Sensors
[2]WorldView 2 Sensor
[3]ITT ENVI, Erdas Imagine
[4]eCognition

2. Object-oriented methodology differs from pixel-based techniques because the intended unit of observation is not the pixel but rather segments of multiple pixels (i.e., objects). While the initial image segmentation uses low-level pixel-based information, it creates higher-level contiguous regions of pixel clusters called "objects" (Benz et al. 2004).

3. A transformation called Minimum Noise Fraction (MNF) identifies extraneous "noise" in the image that can be excluded from subsequent analyses. A Normalized Difference Vegetation Index (NDVI) transformation captures vegetation responses in the proximity of anthropogenic disturbances. A Tasseled Cap Transformation (TCT) detects the preferential trapping of moisture within the rubble mounds of masonry ruins. Matched Filtration (MF) procedures "unmix" a pixel that registers both natural and cultural features with the intent of uncovering a single known anthropogenic spectral signature.

"Fuzzy" classification replaces the binary statements of "true" and "false" with a continuous range between 0 and 1, where 0 stands for "false" and 1 for "true." All values between 0 and 1, then, vary between true and false, representing a fuzzy range. In a fuzzy classification, an object can be considered to be in any class to a certain extent: final classification is based only upon the variables that make the strongest argument (i.e., that best match the training or "known" data).

Literature cited

Ahlstrom, R. V. N., D. E. Purcell, M. Zyniecki, D. A. Gilpin, and V. L. Newton. 1993. An archaeological overview of Grand Canyon National Park. Archeological Report 93-92. SWCA Environmental Consultants, Flagstaff, Arizona, USA.

Anderson, K. C., and T. Neff. 2011. The influence of paleofloods on archaeological settlement patterns during AD 1050–1170 along the Colorado River in the Grand Canyon, Arizona, USA. Catena 85(2):168–186.

Aspinall, A. L., C. Gaffney, and A. Schmidt. 2008. Magnetometry for archaeologists. Altamira Press, Lanham, Maryland, USA.

Benz, U. C., P. Hofmann, G. Willhauck, I. Lingenfelder, and M. Hetnen. 2004. Multiresolution, object-oriented fuzzy analysis of remote sensing data for GIS-read information. Journal of Photogrammetry and Remote Sensing 58(3–4):239–258.

Bishop, K. M., L. J. Graumlich, and W. L. Halvorson. 2011. Defining resource stressor syndromes in southwestern national parks. Park Science 27(3):25–28.

Conyers, L. B. 2004. Ground-penetrating radar for archaeology. Altamira Press, New York, New York, USA.

Fairley, H. C. 2005. Cultural resources in the Colorado River corridor. Pages 177–192 *in* S. P. Gloss, J. E. Lovich, and T. S. Melis, editors. The state of the Colorado River ecosystem in Grand Canyon. U.S. Geological Survey Circular 1282. Reston, Virginia, USA.

Kvamme, K. L. 2008. Remote sensing approaches to archaeological reasoning: Pattern recognition and physical principles. Pages 65–84 *in* A. P. Sullivan III, editor. Archaeological concepts for the study of the cultural past. University of Utah Press, Salt Lake City, USA.

Mink, P. B., II, B. J. Stokes, and D. Pollack. 2006. Points vs. polygons: A test case using a statewide geographic information system. Pages 219–240 *in* M. W. Mehrer and K. L. Wescott, editors. GIS and archaeological site location modeling. CRC Press, New York, New York, USA.

Parcak, S. H. 2009. Satellite remote sensing for archaeology. Routledge, New York, USA.

Sullivan, A. P., III, R. C. Frohn, K. S. Magee, and N. Chaudhary. 2006. Testing the regional reliability of spectral signatures of archaeological phenomena. Final Report (Grant Number MT-2210-05-NC-12) submitted to the National Park Service, National Center for Preservation Technology and Training, Natchitoches, Louisiana, USA.

Sullivan, A. P., III, P. B. Mink II, and P. M. Uphus. 2007. Archaeological survey design, units of observation, and the characterization of regional variability. American Antiquity 72(2):322–333.

About the authors

Alan P. Sullivan III *(alan.sullivan@uc.edu), PhD, is professor and head of the Department of Anthropology, University of Cincinnati.* ***Kevin S. Magee****, PhD, is visiting scientist at the National Geospatial-Intelligence Agency.* ***Philip B. Mink II*** *is GIS manager and staff archaeologist for the Kentucky Archaeological Survey, Department of Anthropology, University of Kentucky.* ***Kathleen M. Forste*** *is an archaeology graduate student in the Department of Anthropology, University of Cincinnati.*

NPS/ERIN BABICH

PARK OPERATIONS

Managing overnight stock use at Yosemite National Park: A science-based approach

By J. Dan Abbe and Liz Ballenger

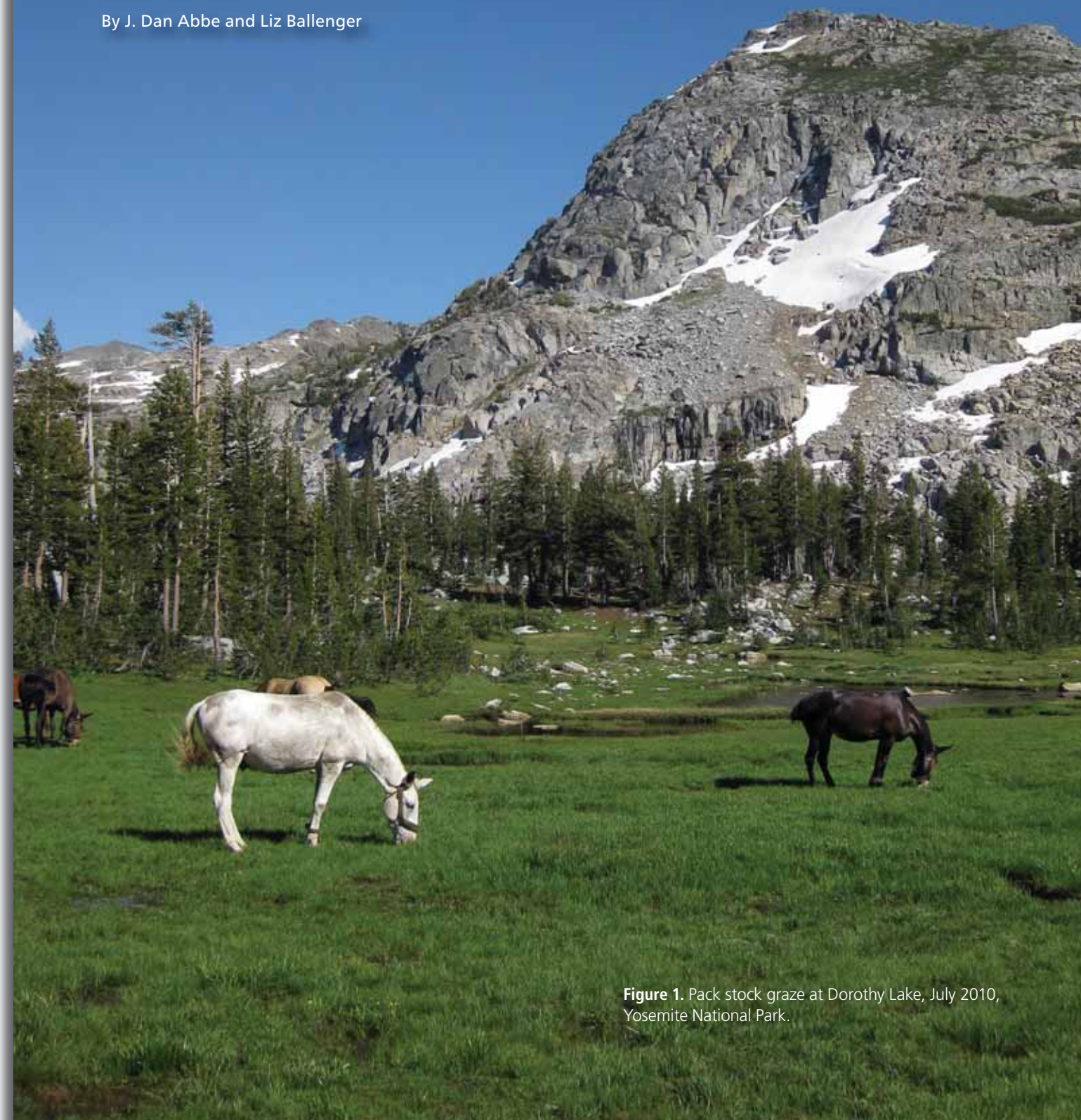


Figure 1. Pack stock graze at Dorothy Lake, July 2010, Yosemite National Park.

Abstract
Pack stock use in Yosemite National Park is an important part of the park's history, an inspirational experience for many wilderness visitors, and a vital element of park operations. Park staff recently identified threats to the ecological integrity of meadows related to high levels of stock grazing. They are working to address this issue by monitoring conditions and implementing a pilot management program in select stock use areas. This article describes how resource managers are calculating initial pack stock capacities for these areas and implementing changes to wilderness stock management. This ongoing quantitative work gives strong support to future management decisions and improves our understanding of overnight stock use and management.

Key words
available forage, Commercial Use Authorization (CUA), forage production, grazing limits, meadows, pack stock use, stock capacities, stock nights, wilderness stock management

NPS

Figure 2. Pack stock at Emeric Lake in Yosemite, August 2006.

PACK STOCK HAVE BEEN PART OF THE HISTORY OF YOSEMITE National Park, California, since the mid-1800s, and they continue to play vital roles in wilderness recreation and park operations. Releasing stock for grazing in meadows is a common practice for overnight stock users (figs. 1 and 2); however, grazing and trampling can negatively affect meadows by decreasing vegetation cover and productivity, shifting plant species composition, damaging streambanks, exposing bare ground, compacting soil, and increasing erosion (Miller and Donart 1981; Kauffman and Krueger 1984; McClaran and Cole 1993; Olson-Rutz et al. 1996; Cole et al. 2004). A recent study in Yosemite identified impacts on subalpine meadows linked to stock use (Ballenger et al. 2010). Park staff is addressing this issue through a science-based pilot stock management program that monitors use levels and area conditions and recommends best management practices to mitigate resource damage. Because commercial pack trips account for approximately half of overnight stock use in Yosemite, the park has used the Commercial Use Authorization (CUA) permit as an interim management tool, as it gives the park superintendent discretion to establish specific terms and conditions of use.

The pilot stock management program focuses on Lyell and Virginia canyons, northeast of Yosemite Valley, where approximately half of the park's commercial stock use occurs. We chose these sites because of high use levels and impacts compared with other areas, diversity of the two areas, and relatively easy access for monitoring. In August 2009, an interdisciplinary team of park biologists, wilderness managers, and trail maintenance staff visited both areas to observe and discuss pack stock issues in the field. As a result the team developed recommendations for management actions, some of which were implemented following management approval the following season. For example, in 2010, Yosemite designated stock camps and holding areas in Virginia and Lyell canyons, identified access routes to and from the camps, and clarified locations of grazing areas. Packers are expected to use the depicted access routes and camp locations, which we provide in the form of maps with GIS locations, as a condition of their CUA permit. The number of sites where stock are permitted was reduced and may help decrease the amount of grazing in meadows until science-based grazing limits can be established.

Determining grazing capacities

Another important aspect of the pilot stock management program is determining grazing capacities to protect against overuse. Grazing capacity models exist for meadows but not for forest understory, making establishment of grazing limits for Yosemite complex.

Pack stock capacities are often expressed in units of stock nights, or the amount of forage that one horse or mule consumes in a night of grazing. For instance, a meadow with a seasonal capacity of 100 stock nights would allow one pack trip with 10 animals for 10 nights. Seasonal capacities can be modeled with this simple equation:

$$\text{Available forage} \div \text{Nightly individual consumption} = \text{Number of stock nights}$$

A recent study in Yosemite identified impacts on subalpine meadows linked to stock use.

An accepted estimate for nightly individual consumption is 32.5 lb (14.8 kg) of vegetation per horse or mule, obtained from range management measures of consumption defined as "animal unit equivalents" (Society for Range Management 1989; Vallentine 1990). Estimating meadow forage production is more complicated because size, vegetation type, elevation, and ecological health ("range condition") all influence production (Ratliff et al. 1987). In addition, "available" forage is less than the total amount of forage produced, since excessive use can lead to the negative effects already mentioned. Cole et al. (2004) found that when grazing exceeded 25% of biomass in some common high-elevation meadow communities at Yosemite, bare ground increased while vegetation cover and productivity decreased. In light of these findings, we adopted this 25% threshold of the total estimated biomass for available forage on preferred species, mainly grasses and sedges such as *Deschampsia cespitosa* (tufted hairgrass), *Calamagrostis breweri* (Brewer's reedgrass), and *Carex vesicaria* (inflated sedge).

In Lyell Canyon, enough information is available to calculate initial capacities based on this model. Pack stock exclusively graze two meadows of known size and elevation adjacent to the stock camps. Vegetation studies in this canyon (Ballenger et al. 2010) evaluated the proportion of meadow occupied by preferred forage species. Data from these studies were adapted to an ecological condition model for meadows (Weixelman and Zamudio 2001) to evaluate range condition of the meadows in this canyon. Estimated forage production rates (pounds per acre) for specific elevations and condition classes of Sierra Nevada meadows (Abbott et al. 2003, adapted from Ratliff et al. 1987) were then multiplied by the area of preferred forage species in the canyon meadows to obtain an estimate of total forage (in pounds). Multiplying total forage by 25% (available forage) and dividing by 32.5 pounds (individual nightly consumption) provides a seasonal stock capacity estimate for Lyell Canyon.

The situation in Virginia Canyon is more complex. Several stock camps are situated along a 3-mile (4.8 km) length of canyon, and stock graze throughout this area of lush forest understory, pocket meadows, and small forest gaps. Determining the size of grazing area for each camp is difficult because published information on evaluating forage production and range condition in forest understories is lacking. Therefore, in 2011, park staff collected data to quantify forage in a quarter-mile buffer around each stock camp in Virginia Canyon. We targeted this zone around the camps because it is the most likely area to be grazed by stock, and it allows us to adapt the stock capacity model for meadows to reflect differences in the concentration of understory forage.

Future planning

Our work to date is a good start to providing a scientific basis for future management decisions regarding grazing limits. Though we can recommend grazing limits for the traditional meadow grazing environments in Lyell Canyon, we need to gather more data and further study the effects of grazing on forest understory in Virginia Canyon. In addition, holding off on establishing limits in these two canyons gives us time to explore methods of mitigating impacts from additional stock that may be needed to carry feed into the backcountry once grazing limits are set, and to address potential displacement of stock to surrounding areas that do not yet have grazing limits. As summer 2012 approaches, plans are moving forward to apply the meadow grazing capacity model to other wilderness meadows at Yosemite and to solicit peer review of the adapted model for calculating capacities for forest understory grazing. Within a few years we expect to be able to apply this modeling technique to establish grazing limits in both meadow and forest understory environments throughout the park.

The management of Lyell Canyon, part of the Tuolumne River corridor, may be affected by the impending Tuolumne River Plan, which will likely incorporate grazing limits and other stock management actions. A draft of this plan is expected to be released for public comment in 2012, and planning will include both broad and focused outreach efforts to engage the public. In addition, Yosemite is in the initial stages of developing a wilderness stewardship plan and expects to begin defining its scope in fall 2012.

The pilot stock use management program has already provided valuable information to park management and is a model intended to shape future management actions throughout the park. Further action, for example the establishment of grazing limits, is needed to continue this positive momentum and implement effective management of overnight stock use in Yosemite National Park.

References

Abbott, L. B., L. D. Pieper, and K. E. Young. 2003. Analysis of Residual Biomass Monitoring Program in Sequoia and Kings Canyon National Parks. Unpublished report. New Mexico State University, Las Cruces, New Mexico, USA.

Ballenger, E., L. Acree, and J. Fischer. 2010. 2008 packstock use assessment of subalpine meadows in the Tuolumne River watershed. Unpublished report. National Park Service, Yosemite National Park, California, USA.

Cole, D. N., J. W. van Wagtendonk, M. P. McClaran, P. E. Moore, and N. K. McDougald. 2004. Response of mountain meadows to grazing by recreational packstock. Journal of Range Management 57:153–160.

Kauffman, J. B., and W. C. Krueger 1984. Livestock impacts on riparian ecosystems and streamside management implications—A review. Journal of Range Management 37(5):430–437.

McClaran, M. P., and D. N. Cole. 1993. Pack stock in wilderness: Use, impacts, monitoring and management. General Technical Report INT-301. USDA Forest Service, Intermountain Research Station, Ogden, Utah, USA.

Miller, R. F., and G. B. Donart. 1981. Response of *Muhlenbergia porteri* to season of defoliation. Journal of Range Management 34(2):91–94.

Olson-Rutz, K. M., C. B. Marlow, K. Hansen, L. C. Gagnon, and R. J. Rossi. 1996. Recovery of a high elevation plant community after packhorse grazing. Journal of Range Management 49(6):541–545.

Ratliff, R. D., M. R. George, and N. K. McDougald. 1987. Managing livestock grazing on meadows of California's Sierra Nevada: A manager-user guide. Leaflet #21421. Cooperative Extension, University of California Division of Agriculture and Natural Resources. Available from http://agris.fao.org/agris-search/search/display.do?f=1989/US/US89342.xml;US8923655.

Society for Range Management. 1989. A glossary of terms used in range management. Third edition. Edison Press, Denver, Colorado, USA.

Vallentine, J. F. 1990. Grazing management. Academic Press, San Diego, California, USA, pp. 278–280.

Weixelman, D. A., and D. C. Zamudio. 2001. Determining ecological status of Sierra Nevada mountain meadows using plant frequency and soil characteristics. Pages 463–470 *in* P. M. Faber, editor. California riparian systems: Processes and floodplain management, ecology, and restoration. 2001 Riparian Habitat and Floodplains Conference proceedings. Riparian Habitat Joint Venture, Sacramento, California, USA.

About the authors

J. Dan Abbe *is wilderness patrol supervisor in the Protection Division, Yosemite National Park, California. He can be reached at (209) 372-0549 and dan_abbe@nps.gov.* ***Liz Ballenger*** *is a biologist with the Resources Management and Science Division at Yosemite. She can be reached at liz_ballenger@nps.gov.*

PS

>> HEINTZMAN, CONTINUED FROM PAGE 92

———. 2008. Men's wilderness experience and spirituality: Further explorations. Pages 55–59 *in* C. LeBlanc and C. Vogt, editors. Proceedings of the 2007 Northeastern Recreation Research Symposium, 15–17 April 2007, Bolton Landing, New York. General Technical Report NRS-P-23. USDA Forest Service, Northern Research Station, Newton Square, Pennsylvania, USA.

———. *In press.* The spiritual dimension of campers' park experience: Management implications. Managing Leisure 17(4). Available at http://www.tandfonline.com/loi/rmle20.

Kellert, S. R. 1998. A national study of outdoor wilderness experience. National Fish and Wildlife Foundation, Washington, D.C., USA. Available at http://www.eric.ed.gov/PDFS/ED444784.pdf.

Marsh, P. E. 2008. Backcountry adventure as spiritual development: A means-end study. Journal of Experiential Education 30(3):290–293.

McDonald, M. G., S. Wearing, and J. Ponting. 2009. The nature of peak experiences in wilderness. Humanistic Psychologist 37(4):370–385.

Riley, M. F., and J. C. Hendee. 2000. Wilderness Vision Quest clients: Motivations and reported benefits from an urban based program 1988–1997. Pages 128–135 *in* A. E. Watson, G. Aplet, and J. C. Hendee, editors. Personal, societal and ecological values of wilderness: Sixth World Wilderness Congress proceedings on research, management, and allocation, Volume II Proceedings. RMRS-P-14. USDA Forest Service, Rocky Mountain Research Station, Ogden, Utah, USA.

Salk, R., I. E. Schneider, and L. H. McAvoy. 2010. Perspectives of sacred sites on Lake Superior: The case of the Apostle Islands. Tourism in Marine Environments 6(2/3):89–90.

Stringer, L. A., and L. H. McAvoy. 1992. The need for something different: Spirituality and the wilderness adventure. The Journal of Experiential Education 15(1):13–21.

Trainor, S. F., and R. B. Norgaard. 1999. Recreation fees in the context of wilderness values. Journal of Park and Recreation Administration 17(3):100–115.

White, D. D., and J. C. Hendee. 2000. Primal hypotheses: The relationship between naturalness, solitude, and the wilderness experience benefits of development of self, development of community, and spiritual development. Pages 223–227 *in* S. F. McCool, D. N. Cole, W. T. Borrie, and J. O'Loughlin, compilers. Wilderness science in a time of change conference, Volume 3: Wilderness as a place for scientific inquiry. Proceedings. RMRS-P-15-VOL-3. USDA Forest Service, Rocky Mountain Research Station, Ogden, Utah, USA.

About the author

Paul Heintzman *is associate professor of Leisure Studies at the University of Ottawa, 125 University, Ottawa, Ontario, Canada K1N 6N5. He can be reached by e-mail at pheintzm@uottawa.ca and by phone at (613) 562-5800, ext. 4251.*

PS

PARK OPERATIONS

Economic impacts of search-and-rescue operations on wilderness management in the national parks

By Whitney Ward, Logan Park, and Evan Coulson

Abstract

Search and rescue has become an integral part of wilderness management for the National Park Service. The NPS conducts thousands of search-and-rescue operations annually, each with impacts and management implications. Economic costs are just one of the many types of impacts that stem from these operations. As wilderness managers conduct search-and-rescue operations, they are faced with significant economic costs. Management options to alleviate some of the associated search-and-rescue costs include using applications of the minimum tool rule and cost sharing with wilderness users.

Key words

management, minimum tool rule, search and rescue, wilderness

WILDERNESS PROVIDES NATURAL, UNDEVELOPED, UN-trammeled, unconfined recreation opportunities in conjunction with a sense of primitiveness and solitude. Effective wilderness management ensures that these qualities endure over time. However, wilderness management, as noted by Nash (1982), is a paradox, meaning that there is human influence in areas where such influence is meant to be absent. Search and rescue (SAR) is just one sphere where the National Park Service (NPS) faces a wilderness management conundrum. Managers are faced with preserving life while preserving wilderness qualities, and often these management objectives are mutually exclusive. Wilderness SAR operations in the national parks can have significant and lasting ecological, social, and economic impacts. This article focuses on economic impacts of search and rescue and proposes feasible approaches to search and rescue and to reduce wilderness impacts.

Economic costs

On 18 June 1998, Denali National Park (Alaska) initiated a rescue of a team of British mountaineers from Mount McKinley. Eight climbers were rescued by helicopter over the course of five days, and two of them required short-haul air rescue from above 19,000 feet (5,975 m) (Denali National Park and Preserve 1998). This rescue cost the National Park Service more than $220,000 and was the most expensive rescue in its history (Huss 2010). This is just one of the approximately 4,500 (SAR) incidents that take place in the national parks annually (NPS n.d.).

Search-and-rescue operations vary dramatically across wildernesses: heli-rescue on Mount McKinley (fig. 1) differs from a cave rescue at Wind Cave National Park (South Dakota) (fig. 2 [next page]). However, one factor is ever present: SAR costs are significant in terms of money and staff time. Each year the Park Service expends 50,000 to 100,000 personnel-hours responding to SAR incidents (NPS n.d.), which cost $4.8 million in 2008 (Repanshek 2010). Search-and-rescue procedures resulting in over $500 in unbudgeted costs are charged to a national SAR account (NPS n.d.). However, even with this account, some SAR operations

COURTESY OF WHITNEY WARD

Figure 1. The "Denali lama" performs a high-altitude short-haul rescue on Mount McKinley in the Denali Wilderness, Denali National Park, Alaska.

impact financial and personnel resources at individual parks. For example, even before performing a record number of SAR operations in 2011 (Associated Press 2011), Grand Teton National Park (Wyoming) climbing rangers noted that SAR costs can result in the elimination of other NPS services and programs (Grand Teton National Park 2007).

Minimum tool rule

The National Park Service administers more than 40% of the 100 million–plus acres (41 million ha) of wilderness (Wilderness.net n.d.) and is consistently confronted with SAR decisions. The 1964 Wilderness Act prohibits motorized and mechanical vehicles even in rescue operations. However, section 4c of the Wilderness Act "provides an exception for the use of 'normally prohibited' uses such as aircraft, motorized equipment, and mechanical transport when it is determined to be the minimum necessary" (Wilderness .net n.d.).

Human life and safety are paramount in NPS SAR policy, but in any case in which a mechanized solution can effectively and safely be minimized or eliminated, the minimum tool rule is satisfied. In some instances the minimum tool rule may also provide a more cost-effective approach. For example, research is in process to determine if full-sized aircraft can be replaced with smaller, less intrusive unmanned aerial vehicles (UAVs) during wilderness searches (Goodrich et al. 2008). If found effective, UAVs would more fully adhere to the minimum tool rule and lower the financial cost of the search phase.

A best-case scenario to adhere to the minimum tool rule would be to eliminate the need for search and rescue. Although it may not be feasible to do this in national parks, it may be possible to reduce the number of SAR incidents. The Park Service already has an outstanding education and information collection system that may minimize SAR incidents. For example, Grand Canyon National Park (Arizona) has tried to educate recreationists about the potential dangers of wilderness by stating, "for those lacking the required skill and judgment this hike offers about a million ways to get into serious trouble in a remote part of the Grand Canyon" (Grand Canyon National Park 2008). Likewise, before granting backcountry permits, other national parks that manage wilderness, like Denali and Apostle Islands (Wisconsin), require recreationists to attend an educational safety orientation. Permits have proven invaluable in SAR operations as a cost-effective means to narrow searches by providing valuable information as to when and where a search should be conducted (Eldorado National Forest 2010).

NPS PHOTO

Figure 2. Search-and-rescue training at Wind Cave National Park, South Dakota.

Who pays?

Considering the cost involved with search and rescue, controversy has arisen over who must cover expenses. Exceptionally expensive operations often serve as triggers, renewing the debate. When the National Park Service did not seek reimbursement from the eight climbers rescued on Mount McKinley, an Alaska senator lobbied for a review of SAR costs in Denali (Huss 2010). In spite of the cost and controversy, the Park Service does not charge visitors for SAR services (NPS 2006). Likewise, most agencies and organizations oppose charging or seeking reimbursement for search and rescue, believing individuals may delay calling for help for fear of being charged. Delays in search and rescue could lead to more dire circumstances for both rescuers and recreationists. Furthermore, the National Park Service may then face obligated rescue, an express duty to provide SAR services to individuals who paid, which could result in litigation and hold the agency liable for unsuccessful search-and-rescue operations (Heggie and Amundson 2009; Huss 2010). Obligated rescue may also limit an agency's ability to determine how and when to best conduct SAR missions, if at all.

While some parks welcome search-and-rescue donations (Grand Teton National Park 2007), the state of Colorado has developed an approach to managing these costs that may prove useful to NPS managers. The state takes a proactive stance on search and rescue and applies a fee on all hunting, fishing, boat, all-terrain vehicle, and snowmobile licenses. The state also offers a Colorado Outdoor Recreation Search and Rescue Card (CORSAR) for other recreationists for a nominal fee (Colorado Department of Local Affairs n.d.), which avoids mandating reimbursement *and* obligating rescue. The card is not insurance but represents

a voluntary donation that helps offset costs of search and rescue or SAR training. Proceeds supplement statewide SAR funds established in 1987 (Colorado Department of Local Affairs n.d.). By contrast, the military absorbs search and rescue into training budgets because SAR missions are valuable training opportunities (Huss 2010; Repanshek 2008).

Conclusion

Prior to passage of the Wilderness Act, Bob Marshall (one of the visionaries of the National Wilderness Preservation System) confronted the delicate balance between freedom and regulation. If too many rules are imposed, then one of the great values of wilderness—freedom—is lost. But if no rules are imposed and users get into trouble, the managing agency may be accused of negligence or, at best, find itself constantly preoccupied with search-and-rescue operations (Marshall as cited in Glover 1986, p. 251).

Marshall understood the paradox associated with wilderness management, especially regarding search and rescue. Search and rescue will continue to be an integral part of wilderness management for the National Park Service and comes with significant costs. Incorporating search-and-rescue operations into training budgets, adding a surcharge to backcountry permits, and establishing a search-and-rescue card are all approaches that can help managers control or defray these costs. Economic impacts specific to wilderness search and rescue can be reduced as managers continue to apply the minimum tool rule, thus leading to the balance of preserving human life while preserving wilderness qualities.

References

Associated Press. 2011. Grand Teton National Park sets search-and-rescue record. 27 August. Deseret News (Salt Lake City, Utah). Accessed 27 August 2011 from http://www.deseretnews.com/article/700174301/Grand-Teton-National-Park-sets-record-for-searches-and-rescues.html.

Colorado Department of Local Affairs. n.d. Purchase a Colorado Outdoor Recreation Search and Rescue (CORSAR) Card. Accessed 16 April 2011 from http://dola.colorado.gov/dlg/fa/sar/sar_purchase.html.

Denali National Park and Preserve. 1998. 1998 annual mountaineering summary. Accessed 15 August 2011 from http://www.nps.gov/dena/planyourvisit/upload/1998_Mtnrg_Summary.pdf.

Eldorado National Forest. April 2010. Desolation wilderness. Accessed 17 August 2011 from http://www.fs.fed.us/r5/eldorado/documents/rogs/rog_wild_deso_regs.pdf.

Glover, J. 1986. A wilderness original: The life of Bob Marshall. The Mountaineers, Seattle, Washington, USA.

Goodrich, M., B. Morse, D. Gerhardt, J. Cooper, M. Quigley, J. Adams, and C. Humphrey. 2008. Supporting wilderness search and rescue using a camera-equipped mini UAV: Research articles. Journal of Field Robotics 25(1–2):89–110.

Grand Canyon National Park. February 2008. Royal Arch Loop. Accessed 17 August 2011 from http://www.nps.gov/grca/planyourvisit/upload/Royal_Arch_Loop.pdf.

Grand Teton National Park. August 2007. Mountaineering. Accessed 22 August 2011 from http://www.nps.gov/grte/planyourvisit/upload/mountaineering_07-c.pdf.

Heggie, T. W., and M. E. Amundson. 2009. Dead men walking: Search and rescue in U.S. national parks. Wilderness and Environmental Medicine 20:244–249.

Huss, S. 2010. Liability in search and rescues: Should individuals who necessitate their own rescues have to pay? Journal of Homeland Security and Emergency Management 7(1): Article 2. Accessed 16 April 2011 from http://www.bepress.com/jhsem/vol7/iss1/2. doi:10.2202/1547-7355,1603.

Nash, R. 1982. Wilderness and the American mind. Yale University Press, New Haven, Connecticut, USA.

National Park Service. 2006. Management policies 2006. Accessed 16 April 2011 from http://www.nps.gov/policy/MP2006.pdf.

———. n.d. Search and rescue. Accessed 16 April 2011 from http://www.nps.gov/policy/SAR.pdf.

Repanshek, K. 12 May 2008. National park search and rescue: Should the rescued help pay the bills? National parks traveler: Commentary, news, and life in America's parks. Accessed 16 April 2011 from http://www.nationalparkstraveler.com/2008/04/national-park-search-and-rescue-should-rescued-help-pay-bills.

———. 31 August 2010. Search and rescue ops cost the National Park Service $4.8 million in 2008. National parks traveler: Commentary, news, and life in America's parks. Accessed 16 April 2011 from http://www.nationalparkstraveler.com/2010/08/search-and-rescue-ops-cost-national-park-service-48-million-20086495.

Wilderness.net. n.d. Wilderness data search results. Accessed 16 April 2011 from http://wilderness.net/index.cfm?fuse=NWPS.

About the authors

Whitney Ward *and* ***Evan Coulson*** *are with the Department of Health Education and Recreation, Southern Illinois University, Carbondale.* ***Logan Park*** *is with the Department of Forestry, also at Southern Illinois University. Correspondence: Whitney Ward (wward@siu.edu), Department of Health Education and Recreation, SIUC, Carbondale, IL 62901.*

Conclusion

COMMENTARY

Through the looking glass: What value will we see in wilderness in 2064?

By Jeff Rose and Dan Dustin

THIS QUESTION IS INCREASINGLY relevant to people around the world as we enter the 21st century and look forward to the 100th anniversary of the Wilderness Act. Domestic and international demographic projections portend a future filled with more people making more demands on Earth's limited store of nonrenewable resources, a problem exacerbated by climate change (Dietz et al. 2003). The assumption that wilderness will always remain secure for its intended purposes rests on democratic processes and the will of the American people.

The National Park Service (NPS), the U.S. Forest Service (FS), the Bureau of Land Management (BLM), and the U.S. Fish and Wildlife Service (FWS) are entrusted with the stewardship of our nation's wilderness. One of their primary charges is to preserve wilderness's "biophysical, experiential, and symbolic ideals" (Landres 2004, p. 9). Protecting wilderness for its multiple purposes, including biodiversity and recreation, is no simple task. Nevertheless, among these purposes the job of the National Park Service is to ensure that national park wilderness forever retains the relatively untouched character of which Thoreau spoke, while also serving as the "geography of hope" that Stegner (1992) imagined it to be.

The National Park Service and the other bureaus are obliged to ensure that the values of wilderness are upheld and that there will always be recreational, scenic, scientific, educational, conservation, cultural, and historical uses of wilderness as codified in the Wilderness Act. However, there is also a philosophical, spiritual, and political base upon which to guarantee the existence of wilderness as a reflection of our national conscience. As Roderick Nash (1967) teaches us in *Wilderness and the American Mind*, wilderness is socially constructed. Wilderness is our psychological response to untrammeled nature as much as it is untrammeled nature itself. It is a decidedly American creation infused with values that many Americans hold dear: a desire for freedom, privacy, solitude, independence, and self-reliance. Wilderness, in this sense, serves as a mirror unto ourselves. It reflects who we were, who we are, and who we aspire to become. But as the United States transforms into an increasingly urban, sedentary, and technologically dependent society, and as many of our children come to prefer the indoors over the outdoors (Louv 2008a; Pergams and Zaradic 2006, 2008; Zaradic 2008), who is to say wilderness will retain the same meanings, the same significance in 2064, as it does today?

As the planet becomes more congested, as space for human habitation becomes scarcer, and as the appetite for resources intensifies, those physical places we call wilderness will become more and more enticing for their natural resources—be they oil, timber, coal, natural gas, uranium, copper, or other precious metals. Paradoxically, wilderness will also become more valuable as a scientific and ecological laboratory, as the best "baseline" against which to measure the advance of civilization. Despite claims that Earth has now entered the "anthropocene," a geological epoch characterized by human impact (Crutzen and Stoermer 2000), wilderness will likely remain the most unaffected of any natural areas in the United States, serving as an important classroom for ecological understanding.

From a broader perspective, wilderness will also be a test tube, a type of philosophical and material experiment in human restraint. Wilderness will likely be valued more as a wellspring, the headwaters from which pure water flows to quench the thirst of an increasingly parched country—especially west of the 100th meridian. But such a practical appraisal of the scientific value of wilderness leaves something to be desired, as there is much that escapes the caliper's claw. Safeguarding wilderness will yield important health benefits to help sustain our species along with several furry, feathery, and flowery others. In this regard, there should be more to us, our sensibilities, our dreams, our spirituality, and to what it means to grow and develop as ethical human beings that manifests itself in our relationship with wilderness.

This brings us back to Nash's (1967) claim that wilderness is more than a space or a place; it is a psychological state of mind. We see in wilderness what we will. We infuse it with our own meanings, and these meanings may change over time. Historically, the existence of wilderness symbolized our civilization's capacity to exercise a modicum of restraint in its otherwise relentless march forward in the name of progress. In a spatial sense, wilderness has been a rare exception to the rule, a geographic concession to modesty doled out by a civilization rich in developmental and

Wilderness is our psychological response to untrammeled nature as much as it is untrammeled nature itself. It is a decidedly American creation infused with values that many Americans hold dear: a desire for freedom, privacy, solitude, independence, and self-reliance.

commercial hubris. It has been a gesture of humility, not unlike a Sunday morning offering following a week of considerable profitability. When it comes to the future of wilderness in the United States, one has to wonder what new concessions, what new gestures, what new offerings we will feel compelled to make in 2064.

Whatever we value in wilderness in 2064, it will not be the result of something that is thrust upon us from the outside—be it crowding, dwindling natural resources, climate change, or biodiversity loss. Rather our values of wilderness will be something we create from within. Wilderness will continue to mean what we want it to mean. Perhaps we will see wilderness much the same way as we envisioned it in 1964. But it is much more likely that our view of wilderness will change with evolving cultures, politics, and social norms. Wilderness in 2064 may well be a function of a highly urbanized, sedentary, technologically transfixed, stay-inside citizenry that embraces fundamentally different core values, a citizenry that is further disengaged from an intimate relationship with the natural world. Should such a future come to pass, then, as Stegner feared, something will have gone out of us as a people. A society increasingly detached from its biological moorings is in danger of thinking it no longer needs nature, much less wilderness. In the end, such a society risks making the mistake of assuming it controls nature and that nature plays only a supporting role in the human drama.

As poets, philosophers, and wilderness visionaries have trumpeted throughout our nation's history, and as science now echoes as well, we humans are part of nature, after all, and our well-being ultimately depends on the welfare of the larger living and nonliving world around us. Ecology teaches us that wilderness—that intricately formed, wonderfully configured landscape of unfettered magnificence—is one of the most telling expressions of what nature and humankind look like when both are in robust health. While the nonhuman world might be healthy without human interference, a healthy society is a constant struggle that requires active engagement. A healthy ecosystem, one that includes both human and nonhuman systems working together, needs active and thoughtful management. The National Park Service is at the forefront of this vitally important work of integrating people into the wild nature that surrounds us. Louv (2008b) calls this "sacred work." Indeed it is.

References

Crutzen, P. J., and E. F. Stoermer. 2000. The "anthropocene." Global Change Newsletter 41:17–18.

Dietz, T., E. Ostrom, and P. Stern. 2003. The struggle to govern the commons. Science 302(5652):1907–1912.

Landres, P. 2004. Developing indicators to monitor the "outstanding opportunities" quality of wilderness character. International Journal of Wilderness 10(3):8–20.

Louv, R. 2008a. Last child in the woods: Saving our children from nature-deficit disorder. Algonquin Books, Chapel Hill, North Carolina, USA.

———. 2008b. National Conference on Outdoor Leadership 2008 keynote address, 15 February 2008. Journal of the Wilderness Education Association 20(1):4–6.

Nash, R. 1967. Wilderness and the American mind. Yale University Press, New Haven, Connecticut, USA.

Pergams, O., and P. Zaradic. 2006. Is love of nature in the U.S. becoming love of electronic media? 16-year downtrend in national park visits explained by watching movies, playing video games, Internet use, and oil prices. Journal of Environmental Management 80(4):387–393.

———. 2008. Evidence for a fundamental and pervasive shift away from nature-based recreation. Proceedings of the National Academy of Sciences of the USA 105(7):2295–2300.

Stegner, W. 1992. A geography of hope. Pages 218–229 *in* G. Holthaus, P. Limerick, C. Wilkinson, and E. Munson, editors. A society to match the scenery: Personal visions of the future of the American West. University Press of Colorado, Boulder, Colorado, USA.

Zaradic, P. 2008. Confronting videophilia. Scientific American 18:24.

About the authors

Jeff Rose *recently received his PhD from the Department of Parks, Recreation, and Tourism at the University of Utah, Salt Lake City. His research employs political ecology to examine public space and nature-society relations under neoliberalism.* ***Dan Dustin*** *is chair of the Department of Parks, Recreation, and Tourism at the University of Utah, Salt Lake City. He is the author of several books that examine the values and ethics underpinning the management of our nation's wildlands.*

PS

PARKScience
Integrating Research and Resource Management in the National Parks

National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science
Office of Education and Outreach

We hope you enjoy this issue of *Park Science*

There are four ways to

- **Subscribe**
- **Update your mailing address**
- **Submit manuscripts and letters**

(Use your subscriber number on the delivery envelope for easy subscription updates.)

1. Online
www.nature.nps.gov/ParkScience
Click "Subscribe."
Note: If the online edition of *Park Science* will meet your needs, select "e-mail notification."
You will then be alerted by e-mail when a new issue is published online in lieu of receiving a print edition.

2. E-mail
jeff_selleck@nps.gov
Include your subscriber number, name, and address information.

3. Fax
303-987-6704
Use this page and make any necessary changes to your address information.

4. Mail
Send this page along with any updated address information to the editorial office address below.

PARKScience
c/o Jeff Selleck
National Park Service
NRSS/OEO
P.O. Box 25287
Denver, CO 80225–0287

WINNER 2010 APEX AWARDS FOR PUBLICATION EXCELLENCE

FIRST-CLASS MAIL
POSTAGE & FEES PAID
National Park Service
Permit G-83