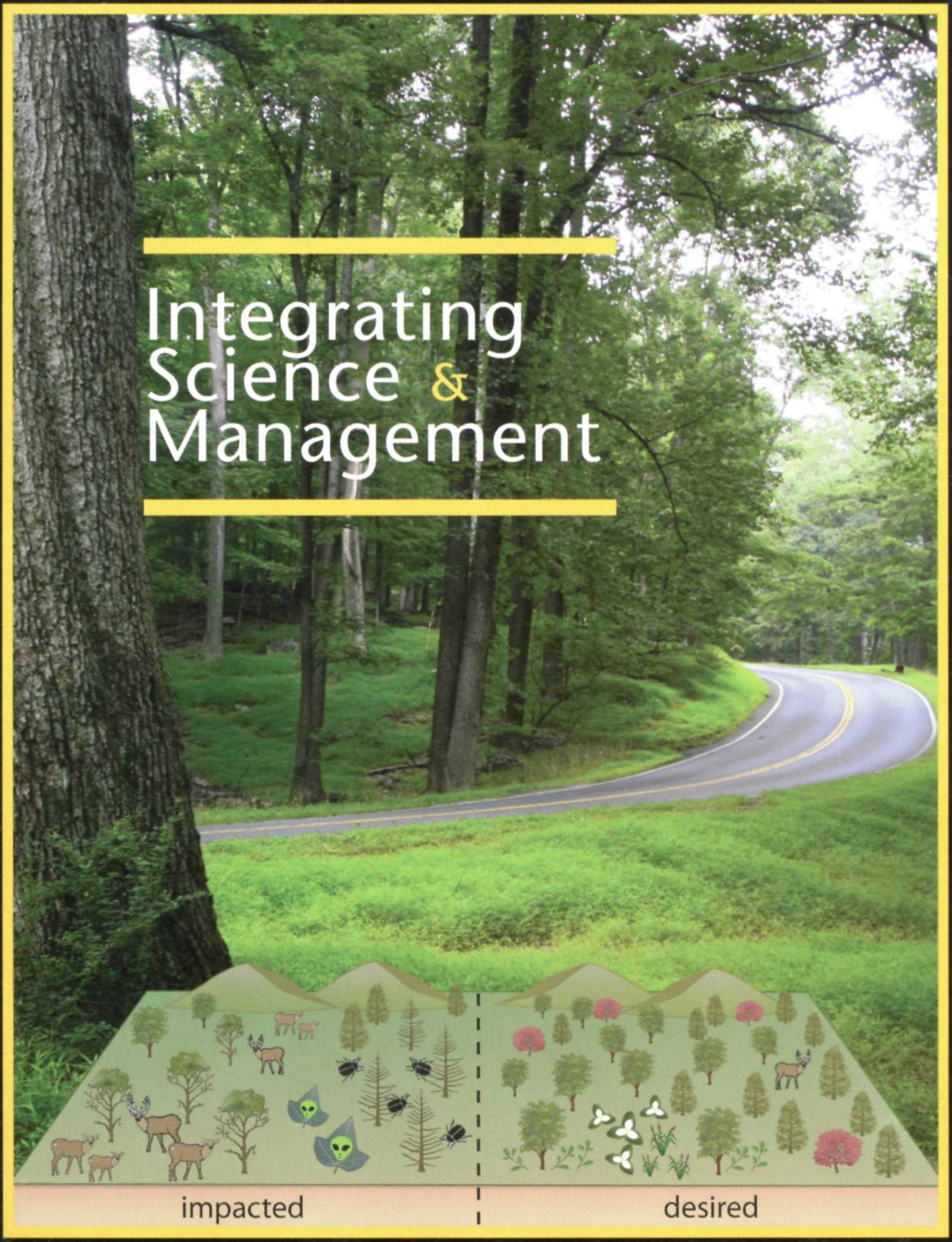

The George Wright Forum

The GWS Journal of Parks, Protected Areas & Cultural Sites

volume 24 number 2 • 2007

GEORGE
WRIGHT
SOCIETY

Origins

Founded in 1980, the George Wright Society is organized for the purposes of promoting the application of knowledge, fostering communication, improving resource management, and providing information to improve public understanding and appreciation of the basic purposes of natural and cultural parks and equivalent reserves. The Society is dedicated to the protection, preservation, and management of cultural and natural parks and reserves through research and education.

Mission

The George Wright Society advances the scientific and heritage values of parks and protected areas. The Society promotes professional research and resource stewardship across natural and cultural disciplines, provides avenues of communication, and encourages public policies that embrace these values.

Our Goal

The Society strives to be the premier organization connecting people, places, knowledge, and ideas to foster excellence in natural and cultural resource management, research, protection, and interpretation in parks and equivalent reserves.

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On the cover:
A roadside in Catoctin Mountain Park, Maryland, where the forest understory is dominated by the invasive alien plant Japanese stiltgrass *(Microstegium vimineum).* How to manage invasive plant species is a typical park resource problem that requires close coordination between scientists and managers. The photo dates from 2006. Photo by Thomas Paradis; diagrams originally by Jane Hawkey.

SOCIETY NEWS, NOTES & MAIL

Record crowd attends GWS2007

We met in the middle … and the result was outstanding.

For the first time since we began organizing the GWS biennial conferences in 1982, the Midwest was the venue, and the response was a record crowd of more than 900 attendees. The 2007 George Wright Society Conference on Parks, Protected Areas, and Cultural Sites was held in St. Paul, Minnesota, during the week of April 16–20. Bolstered by concurrent meetings of superintendents from the National Park Service's Midwest Region and by the NPS Inventory & Monitoring Network, GWS2007 was a dynamic event. There was a real buzz in the hallways, fired by a strong program of plenary and concurrent sessions, posters, computer demos, and exhibits.

The theme, "Rethinking Protected Areas in a Changing World," focused attention on the large-scale transformations affecting the world today, such as climate change, demographic shifts, and the democratization of heritage. Attendees listened to a series of challenging plenaries, whose speakers included Lisa Graumlich of the University of Arizona, Canadian conservationist Harvey Locke, Bobbie Conner of the Tamástslikt Cultural Institute, Charles Hudson of the Columbia River Intertribal Fish Commission, former Parks Canada CEO Tom Lee, former National Park System Advisory Board member Daniel L. Ritchie, former National Public Radio producer Bebe Crouse, and Charles C. Mann, author of the best-selling *1491: New Revelations of the Americas Before Columbus.*

All the plenary sessions at GWS2007 drew large crowds. The Thursday morning plenary was on communicating park issues. Here, featured speaker Bebe Crouse (l) listens as session moderator and GWS Board member Suzanne Lewis reads a question from the audience. Photo © 2007 Charles D. Rafkind (photocdr@yahoo.com).

Once again, a cadre of promising advanced students from ethnically, racially, and culturally diverse backgrounds added energy and depth to the meeting through their attendance as George Melendez Wright Student Travel Scholarship winners. Additional new perspectives were offered by the inaugural group of recipients of Native Participant Travel Grants. This new program was conceived and led by GWS member Sharon Franklet, and underwritten by generous grants from the NPS Pacific West and Alaska Regions. The NPTG program brought 13 indigenous participants, each active in protecting, managing, or studying the land, its biological/cultural systems, or Native land rights. A track of sessions focusing on Native issues wove through the concurrent schedule, and a thought-provoking and enjoyable Native Film Night provided an opportunity for people to come together and share thoughts and feelings.

The George Melendez Wright Student Travel Scholarship is one of the most important new initiatives we've launched in recent years. Our conferences now benefit from the insights of a diverse group of upper-level undergraduate and graduate students who come from ethnic, racial, and cultural backgrounds that historically have not been well-represented in the park professions.. The scholarship winners, their mentors, and others gathered for a luncheon on Tuesday afternoon. GWS Board member Gillian Bowser, who was instrumental in creating the scholarship program and making it a success, is third from the left in the front row. Photo © 2007 Charles D. Rafkind (photocdr@yahoo.com).

The debut of the Native Participant Travel Grant (NPTG) program brought about a dozen indigenous delegates from around North America to GWS2007. Like the Student Travel Scholarship, the NPTG program is a breakthrough for GWS. Here, GWS member Sharon Franklet, who conceived and organized the NPTG, addresses a welcoming/orientation meeting for grantees and other interested attendees. Photo © 2007 Charles D. Rafkind (photocdr@yahoo.com).

"Imagine Excellence": The 2007 round of the GWS awards program

The Science Museum of Minnesota, an impressive facility on the banks of the Mississippi, was the setting for the 2007 GWS Awards Banquet. The event was held jointly with the NPS's presentation of its Director's Awards for Natural Resources and the presentation of an Honorary Park Ranger Award to Walter Mondale, former vice president of the United States. The GWS award winners were:

- The George Wright Society Communication Award: Harry Butowsky, for developing the National Park Service History website with more than 2,000 full-text books and other documents, many of them rare.
- The George Wright Society Cultural Resource Management Award: Nelly Robles Garcia, for her leadership in the professionalization of cultural resources management in Mexico and throughout Latin America. (Dr. Robles Garcia was unable to attend and therefore is not pictured below.)
- The George Wright Society Natural Resource Management Award: Charles van Riper III, for his many and varied research contributions to national parks and for his leadership in connecting research findings to management outcomes.
- The George Wright Society Special Achievement Award: Gary E. Machlis, for his outstanding record of social science research, his role in developing the Cooperative Ecosystem Studies Units Network, and his role in creating the Canon National Parks Science Scholars Program.
- The George Melendez Wright Award for Excellence, the Society's highest honor: George B. Hartzog, Jr., for his history-making contributions to the expansion and development of the national park system during his tenure as the seventh director of the National Park Service.


Left: GWS President Abby Miller with the Communication Award winner, Harry Butowsky. Right: Special Achievement Award winner Gary E. Machlis with Miller. Photos © 2007 Charles D. Rafkind (photocdr@yahoo.com).

Left: Natural Resource Management award winner Charles van Riper III, with his daughter, Carena. Right: Because of health reasons, former NPS Director Hartzog was unable to attend the ceremony. His son, George B. Hartzog III, accompanied by his own son, Dietrich, accepted the George Melendez Wright Award for Excellence on Director Hartzog's behalf. Photos © 2007 Charles D. Rafkind (photocdr@yahoo.com).

The three North American federal park directors participated in a plenary earlier in the day and were guests of honor along with Vice President Mondale and Mrs. Joan Mondale at the banquet. Left to right: Mr. Mondale; Mary Bomar, director of the U.S. National Park Service; Ernesto Enkerlin Hoeflich, president of Mexico's Comisión Nacional de Áreas Naturales Protegidas; and Alan Latourelle, chief executive officer of Parks Canada. Photo © 2007 Charles D. Rafkind (photocdr@yahoo.com).

The complete banquet program, with full citations of all the GWS and NPS winners, can be downloaded at www.georgewright.org/gws2007_banquet.pdf. Nominations for the next round of awards will be accepted starting in June 2008.

GWS to revise Strategic Statement this fall — your ideas wanted!

Every five years, the Society's Board of Directors reviews and updates the GWS Strategic Statement, a short (2-page) outline of our key activities and goals. The Strategic Statement starts with a description of our origins, mission, and goals (these can be found on the inside front cover of every issue of *The George Wright Forum)*. It continues with a discussion of continuing and new objectives for the products and services we deliver to our members and others, the governance of the Society through the Board and executive office, and plans for partnerships, advocacy, finances, and communications. You can read the Strategic Statement at **www.georgewright.org/strategic.html.**

At the Board's annual meeting this October we will hold a planning retreat during which we will revise the Strategic Statement for the period 2008–2012. We are actively seeking advice from GWS members on what we should emphasize in the revision. What are the key issues you want us to focus on? Are there things we should be doing that we aren't doing now? What, in short, do you want your George Wright Society to be? Please send your thoughts and ideas to GWS executive director Dave Harmon (dharmon@georgewright.org) by August 31.

On the Brink of Greatness: National Parks and the Next Century

Dwight T. Pitcaithley

ALMOST A HUNDRED YEARS AGO, just before the creation of the National Park Service, the British ambassador to the United States, James Bryce, spoke to the American Civic Association on the subject of national parks and their importance to society. With great simplicity, he acknowledged the obligation to "carefully guard what we have got." "We are the trustees for the future," he charged. "We are not here for ourselves alone. All these gifts were not given to us to be used by one generation, or with the thought of one generation only before our minds. We are the heirs of those who have gone before, and charged with the duty we owe to those who come after...."[1] As this country begins to think about the centennial of the National Park Service, it is appropriate that we have a serious conversation about parks and their value to our society, and the role we want parks and the National Park Service to play in the future. What is our obligation, as the trustees of these magnificent places, to our children and their children? The upcoming centennial provides an opportunity to think creatively about the kind of National Park Service we want for the next century and envision systemic changes for its betterment and ours.

The one-hundredth birthday of the National Park Service should be cause for a national celebration. It should prompt us to imagine a future for the agency and the magnificent collection of parks and programs it manages based not on the vision of a hundred years ago, but on the reality of today. That realistic vision should embrace the complexity of managing parks within an ever-increasing array of congressional mandates, within ever-changing national cultural demographics, within evolving scientific and scholarly studies that continuously refine our understanding of the world around us and our sense of who we are as a society. And most of all, that vision of the future should recognize the intricate interrelationships between the natural and human spheres and how human actions are having increasingly negative effects on our small ball of a planet.

The National Park System today is vastly different from the one envisioned and managed by Stephen T. Mather and Horace M. Albright ninety years ago. The complexity of issues confronted by park and program managers today could not have been envisioned by the first generation of Park Service administrators. The agency that began in 1916 managing thirty-seven parks and monuments now cares for almost four hundred parks within nearly two dozen different categories. National Park Service administrators now manage parks and programs within a complex mix of congressional directives in a variety of areas including wilderness, clean air and water, protection of archeological resources, historic preservation, endangered species, wild and scenic rivers, and environmental protection.

Over the past nine decades, the National Park Service has evolved from an agency that managed a handful of natural parks and a small number of Southwestern archeological monuments into the nation's premier protector and preserver of places nationally and internationally significant for their natural and cultural resources. The Park Service administers eighty-four million acres in every state (except Delaware) and the United States territories of American Samoa, Guam, Puerto Rico, and the Virgin Islands. It now thinks in terms of ecological integrity and civic engagement and sustainable technologies and practices, terms and concepts completely unknown to Mather and Albright. Indeed, those first two directors of the agency would be surprised to learn that 60% of the three hundred and ninety-one units of the national park system were set aside by Congress and presidents to preserve archeological and historic properties. Undoubtedly they would also be astonished at the Park Service's management of conservation and preservation programs beyond park boundaries that nurture the nation's cultural and natural heritage. Programs such as Rivers and Trails, National Heritage Areas, the National Register of Historic Places, National Natural and Historic Landmarks, the Historic American Buildings Survey, and Preservation Assistance encourage and support the preservation of natural and cultural resources in towns and cities throughout the country.

The creation of a national park is an expression of faith in the future.[2] As Lord Bryce remarked, it is a commitment made by one generation to future generations, for their children and grandchildren. The collection of national parks today is a reflection of who we have been—our towering successes, our failures, our aspirations. National parks tell the story of the American people. The National Park Service has come to the realization, over the past ninety years, that preservation of these special places is not the only goal of park creation. Rather, we preserve parks because they have stories to tell—stories of human triumph and folly, stories of environmental nurturing and degradation—and we have things to learn from those stories.[3]

In 2001, a report from the National Park System Advisory Board observed that national parks "should be not just recreational destinations, but springboards for personal journeys of intellectual and cultural enrichment." The National Park Service, over the past several decades, has come to the realization that parks offer more than comfortable places to vacation. National parks possess the very democratic values upon which this country was built, environmental lessons with the potential to make our communities more livable, civic messages that will move us toward "that more perfect Union" imagined over two hundred years ago. Parks, the Advisory Board report reminds us, "offer citizens of all ages opportunities to strengthen their connections to the environment and to renew their sense of wonder and appreciation for our democracy." As we are increasingly forced to confront the fragility of our earth's environment and the malleable nature of our evolving democracy, we should appreciate and nurture the capacity of parks to become models of healthy and sustainable ecosystems and to act as "classrooms" where this nation's journey of liberty and justice become an essential part of our civic education.[4]

As we envision a future for the National Park Service, we must logically consider the problems that currently plague it—primarily those of inadequate budgets and increased politicization. While Congress is enamored with the idea of new parks, it has never felt obligated to support those parks with adequate and consistent funding. In 1953, the writer Bernard DeVoto, then a member of the National Park System Advisory Board, railed about the post-war under-funding of the national park system in an article in *Harper's Magazine* titled "Let's Close the National Parks." Over fifty years ago, DeVoto wrote:

> The crisis is now in sight. Homeopathic measures will no longer suffice; thirty cents here and a dollar-seventy-five there will no longer keep the national park system in operation. I estimate that an appropriation of two hundred and fifty million dollars, backed by another one to provide the enlarged staff of experts required to expend it properly in no more than five years, would restore the parks to what they were in 1940 and provide proper facilities and equipment to take care of the crowds and problems of 1953. After that we could take action on behalf of the expanding future and save from destruction the most majestic scenery in the United States, and the most important field areas of archeology, history, and biological science.[5]

Fortunately for the national parks, President Dwight Eisenhower joined with NPS Director Conrad Wirth in 1956 to announce Mission 66, an eleven-year, one-billion-dollar program to improve physical facilities in parks. (While Mission 66 provided significant staff increases for interpretation, maintenance, and protection, its primary goal was the development and construction of park facilities.) Designed to prepare the parks for the fiftieth anniversary of the National Park Service in 1966, Mission 66 provided a badly needed infusion of funds to an agency that had suffered deep budget cuts during World War II. While the majority of Mission 66 funding was dedicated to capital development projects and not to building the capacity of the organization, the overall budget of the agency did increase, over the decade, by 150%.

After 1966, funding for the National Park Service never kept pace with the growing needs of the agency. During the thirty years following the end of Mission 66, approximately 150 parks were added to the system, including thirteen huge parks and preserves in Alaska which alone doubled the acreage administered by the National Park Service![6] The Alaska National Interest Lands Conservation Act signed by President Jimmy Carter in 1980 added forty-seven million acres to a national park system that even then was unable to care properly for the resources entrusted to it. With the addition of these and other parks came heightened obligations to inventory the parks' natural and cultural resources, create and organize collections, attend to preservation and restoration needs, and develop educational programs and media. While congressional appropriations increased, they did so gradually, and were constantly eroded by inflationary factors. Indeed, seventeen times since 1970, NPS appropriations failed to keep pace with inflation. During the remaining years, with few exceptions, the NPS budget stayed just ahead of inflation.

The chronic under-funding of the National Park Service has been well-documented by the National Parks Conservation Association (NPCA) and the NPS itself. A decade ago, the National Park Service prepared studies of its present abilities to manage the natural and cultural resources entrusted to it. The reports, titled *Natural Resource Management Assessment Program* (NR-MAP; 1995) and *Cultural Resource Management Assessment Program* (CR-MAP; 1997), determined that the Park Service employed only 25% of the staff needed to provide professional attention to natural resources and only 22% of the staff needed to care for its cultural resources!

More recently, the National Park Service, in partnership with NPCA and other organizations, has prepared "business plans" for a number of parks designed to analyze the financial history of individual parks and determine the level of funding necessary to manage its resources within "appropriate standards." The results are not surprising. Among the almost one hundred parks that were studied, the budget shortfall is averaging 32%! Yellowstone's is 35%, Gettysburg's 35%, Everglades's 32%, Valley Forge's 36%, Acadia's 53%, Fort Sumter's 24%. Practically speaking, this means that the national parks have been operating on only two-thirds the funding required to preserve, research, and interpret to the visiting public their collection of incomparable resources.

Finally, the NPS has been struggling for years to address the so-called "maintenance backlog," the funding required to attend to the deferred maintenance of visitor centers and other administrative buildings, roads and trails, housing, water and wastewater systems, as well as archeological sites and monuments. In 2003, the Government Accounting Office (GAO; after July 2004 known as the Government Accountability Office) reported the deferred maintenance backlog at "over $5 billion." The NPCA currently estimates the backlog at between $4.5 and $9.7 billion. The National Park Service estimates its backlog at $8 billion. By any measure, the $2.4 billion in President Bush's 2008 budget proposal, while generous when compared with recent NPS budgets, will not make much of a dent in this monumental shortfall. Moreover, if GAO's 2003 estimate were correct and the National Park Service's 2006 estimate were correct, the deferred maintenance backlog would be growing at a rate of approximately one billion dollars every year!

To complicate the management of this collection of very special places, the National Park Service for the past thirty-five years has been progressively influenced, not by scientific and scholarly recommendations, but by political directives. The degree to which politics increasingly influences National Park Service decisions was noted as early as the 1980s when Wallace Stegner observed trouble within the national parks. "Public pressures increase geometrically, appropriations arithmetically," he astutely observed. "And as its problems increase," he continued, "the Park Service has been increasingly politicized."[7] Consider, then, that the first director of the National Park Service served under three presidents. From 1916 until 1972, a period of fifty-six years, seven different directors guided the activities of the agency through nine different presidential administrations. The turnover rate in recent years has increased exponentially. Between 1980 and today, a period of twenty-seven years, there have been seven directors for four presidential administrations! The rapid turnover in directors means that essential relationships between the NPS and Congress and interested support organizations, not to mention funding priorities, change with the administrations and that the focus of the agency shifts with political winds. These changes at the very top of the agency create a degree of instability in an organization that can only be successful in a future characterized by certainty and consistency.

The NPS director increasingly makes major decisions affecting park resources based on political considerations rather than the requirements of the ecosystems and cultural properties under his/her charge. The recent attempt to rewrite the Park Service's *Management Policies* to conform more closely to the current administration's interests in commercializing parks—an effort which received extraordinary and universally negative national news coverage —is only one egregious example. (Only a change in the position of the secretary of the interior, from Gale Norton to Dirk Kempthorne, saved the Park Service from a disastrous weakening of principles that have guided the agency for seventy years.) The appropriate number of snowmobiles allowed in Yellowstone is being determined less by scientific analysis, and more by political influences. In recent years, many essential career positions throughout the National Park Service were deemed suitable for privatization. Biologists and geologists, archeologists and historians and others, whose collective experience and knowledge of park resources built over decades is critical to the "unimpaired" nature of parks, were slated to be replaced by private-sector contractors. (The extent to which politics has entered the day-to-day operation of the National Park Service was the subject of *National Geographic* in its October 2006 issue titled "Threatened Sanctuaries: The State of the U.S. Parks.")

The problems facing the National Park Service as it begins to think about its one-hundredth birthday help us imagine reasonable solutions. Indeed, the Park Service has been envisioning a healthier and more professional future for itself for some time through a number of thoughtful reports. One outgrowth of the Park Service's celebration of its seventy-fifth anniversary was the production of *National Parks for the 21st Century: The Vail Agenda* (1992). Beginning with the statement that the Park Service was increasingly called upon to "play a broad role of preserving, protecting, and conveying to the public the meaning of those natural and cultural resources that contribute to the nation's values, character, and experience," the report created six categories of objectives that would lead to excellence throughout the agency. Those six categories and their objectives—resource stewardship and protection, access and enjoyment, education and interpretation, proactive leadership, science and research, and professionalism—remain relevant and largely unrealized today. A decade later the National Park Service Advisory Board, under the direction of John Hope Franklin, produced *Rethinking the National Parks for the 21st Century* (2001).

This report created a fresh and clear vision of the role that a well-funded and professionally managed agency might play in American society. It concludes by encouraging the Park Service to expand its horizons and think more expansively and creatively about its work as it faces the challenges of the next century.

> As a people, our quality of life—our very health and well-being—depends in the most basic way on the protection of nature, the accessibility of open space and recreation opportunities, and the preservation of landmarks that illustrate our historic continuity. By caring for the parks and conveying the park ethic, we care for ourselves and act on behalf of the future. The larger purpose of this mission is to build a citizenry that is committed to conserving its heritage and its home on earth.

In 2005, the National Parks Conservation Association produced its own report (with recommendations) on the future of the National Park Service, titled *From Sea to Shining Sea*. Along with full funding of the NPS, *From Sea to Shining Sea* recommends strengthening the core functions of preservation, research, and education in order to meet the highest standards in "sound management, aggressive resource protection, and innovative public initiatives." The existence of these reports allows one to envision a second century for the National Park Service based on a wide foundation of studies and projections.

There will be many proposals for marking the centennial milestone and the process will undoubtedly involve, over the next decade, modifications to all of them. Before any one plan is made final, however, this country needs to have a very open and public conversation about its expectations and hopes for the future. That process began formally in March 2007 with the announcement by the current director of the National Park Service, Mary Bomar, and Secretary of the Interior Kempthorne of a nation-wide series of public "listening sessions." Held around the country, these public gatherings have been designed to assist the National Park Service in planning for its future.

Anniversaries are a time for reflection and reassessment. The one-hundredth anniversary of an institution such as the National Park Service is an occasion for collective reflection on the part of the country in general, and the Park Service in particular.[8] As the trustees of this collection of places that define us as a society and provide such potential for promoting an informed citizenry, what is our vision of the future? Given the myriad problems facing this troubled agency, now is the time for bold action. Now is the time to envision a healthy and vigorous National Park Service for the twenty-first century. To that end, the leadership of the Park Service should explore every aspect of the operation of its parks and programs and recommend steps to strengthen the agency so that it once more becomes the nationally and internationally recognized leader in natural and cultural resource preservation. It is hoped that the unfolding conversation over the next few months and years will challenge all of us to imagine a professionally managed and well-funded Park Service capable of attaining the highest standards in preservation, research, and education.

Centennial thoughts

As we begin thinking about the next century, the following constitute a few thoughts on how the National Park Service might be fortified to prepare for both current and future challenges. Basic to the Park Service's future is, of course, funding. Over the next decade, Congress must attend to the dismal current budget of the agency, an agency which for decades has operated within a culture of poverty. Fundamental to the continuance of parks and their resources unimpaired is increased and consistent funding in the three principal management areas: protection and preservation, research, and education. Moreover, any projected budget for the national park system must address the huge maintenance backlog and provide for consistent future funding to ensure that the backlog is not only reduced, but that the Park Service has adequate funding to maintain its facilities and resources to the highest standards. Future budgets must also acknowledge that the preservation of these special places involves trained personnel in the several resource management fields. The resource assessments, (NR-MAP and CR-MAP) mentioned above, should be unpacked and updated and factored into future budget packages.

Research

Research is fundamental to the National Park Service's mission. Understanding the condition, evolution, and history of its resources is essential to resource management efforts, yet it was not until 1998 that the agency obtained specific authorization from Congress to establish a "scientific study" program.[9] Because research is critical to park preservation decisions and to the development of thoughtful and thought-provoking educational programs, funding at the park, regional, and national levels should be strengthened significantly. To ensure continued access to on-going research outside of the national park system, the ability to develop and maintain cooperative relationships with related organizations, universities, and scholarly institutions must be supported philosophically and financially. The Park Service must maintain a credible scholarly stature in all its disciplines. The failure of the Park Service, early in 2006, to renew its twenty-year cooperative agreement with the Society for American Archeology is shortsighted, and intellectually weakens the agency.

The intricate relationship between research and resource management is eloquently presented in the National Park System Advisory Board's *National Park Service Science in the 21st Century* (2004). Building on the Natural Resource Challenge, a multi-year effort by Congress to improve natural resource management in the parks with the infusion of sorely needed funds, this report evaluates the Challenge and provides recommendations for future directions. Its recommendations, crafted by a nationally recognized committee of scholars, provide a blueprint for strengthening science in the parks. It argues persuasively that "the National Park Service [should] raise to a new level its commitment to the fundamental purpose of preserving the parks unimpaired for all time." The centennial offers a timely opportunity to establish that new level of professionalism—and funding—throughout the national park system. To provide the same level of scholarly evaluation to the system's cultural resources, the Advisory Board should be asked to develop a parallel report with recommendations to guide the future of the humanities and cultural resource management within the Park Service.

Education

The National Park Service has recently completed two documents designed to strengthen its interpretation and education program. *Interpretation and Education Renaissance Action Plan* and *Interpretation and Education Program Business Plan* (both published in late 2006) readily admit that the Park Service "lacks the fundamental tools and resources to fulfill its educational responsibilities." Funding and personnel lag far behind what they should be for an agency with education as a fundamental mission. Park films, publications, and exhibits are often thirty years old and remain in use long after scientists, scholars, and park managers have determined they contain either outdated or inaccurate or inappropriate information. The funds to keep exhibits and other interpretive media current have been dwindling for years. Planning for the centennial should include budgets sufficient to keep park interpretive media relatively current, and equip National Park Service interpreters and educators with the subject-matter knowledge and interpretive skills required for developing creative and challenging educational programs and media. It should emphasize the central function of education to the National Park Service mission, to erase any ambiguity in that obligation and prevent education from being perceived, as it was under the former secretary of the interior, as mission creep. A renewed vision for the future should also include authorization and funding (similar to that employed by the Department of Defense) for the National Park Service to send its employees—in all disciplines—back to institutions of higher learning to seek advanced degrees so the agency can manage its resources and programs with the very best of current science and scholarship. Used extensively by military personnel, this authorization is essential if national parks are to be preserved and maintained "unimpaired" for future generations.

Funding

Having suggested that increased funding is essential for the National Park Service to meet its obligations to Congress and the American public, one must ask what the appropriate level of funding for the agency ought to be. The president's current budget proposal calls for a dedicated increase over the next decade of $1 billion in federal funding with another $2 billion of possible funding through a matching arrangement involving private/public money. (Because of the conditional nature of the second part of this proposal, it cannot contribute to any reliable future funding projections.) If approved by successive Congresses, this federal commitment would raise the overall budget by 2016 to around $3.5 billion. With the operating shortfall for park operations estimated at somewhere between $600 and $800 million and the deferred maintenance backlog estimated at somewhere between $5 and $8 billion, a total budget of $3.5 billion remains substantially inadequate. Estimating budgets, of course, is no small task. One way to conceptualize a well-funded National Park Service, however, is to consider that the 1966 budget for the agency at the end of Mission 66 was just over two and half times the budget in 1956. Applying the same growth factor to the 2006 budget results in a 2016 budget of $6 billion![10]

With the tools at its disposal and with much spadework already done, the National Park Service should develop an optimal and annotated budget, dependent on *consistent public funding*, as a centennial target. A budget of $5–6 billion does not seem unreasonable given the requirements and rising costs of maintaining 20,000 buildings, almost 1,000 campgrounds, 1,600 wastewater systems, 1,300 water systems, 115,000,000 objects, 67,000 archeological sites, and 26,000 historic structures. Furthermore, the complex demands placed on parks by a panoply of congressional legislation and the role many envision the Park Service playing in American society all point to a 2016 budget far healthier than the one currently envisioned. Such a centennial budget would embrace full public funding of the Park Service and national park system. It would, appropriately, abandon the Recreation Fee Demonstration Program. This user fee is inherently inequitable. In a democracy such as ours, the educational and recreational benefits of the national park system should not be available only to those who can afford them. The riches of the national parks should be available to all without reference to economic status. The educational values found in national parks better us as a people and lead to a more informed citizenry. As the National Park Service has recently acknowledged, there is civic value in national parks, and if we as a society are to benefit from those values entrance fees to parks should be abolished.

The entrance fee program was designed to add critically needed funds to a financially strapped National Park Service without increasing the Park Service's budget, and it produces roughly $150 million annually. Yet there are no similar entrance fees to the National Archives or the Smithsonian Institution. Our federal highway system could reap a harvest of "off-budget" funds by erecting toll booths on the interstate highway system; our public school system could do the same by charging tuition to the nation's children. We do not do that because of the pride we have in both of those national institutions and the belief that both should be publicly funded and free to those who take advantage of them.[11] Why should our national parks be different? Furthermore, funding the basic requirements of the National Park Service constitutes such a small fraction of the operations of the federal government that if the current budget were doubled to $5 billion, that figure would amount to less than 0.002% of the president's proposed 2008 budget! Proper funding of the National Park Service is not about money; it is about priorities. National parks are important to the ecological and civic health of this nation and should be funded with public monies.

Independence

Unless, however, something is done regarding the governing structure of the National Park Service and its susceptibility to political influence, the agency will never attain the excellence in preservation, research, and education expected of it for the next century. Balancing the goals of the National Park Service with the incompatible needs of other Department of the Interior agencies—such as the Office of Surface Mining, Mineral Management Service, and the Bureau of Reclamation—creates an environment in which the National Park Service is incapable of reaching its fullest potential.[12]

Perhaps it is time to have a conversation about where in the federal government the agency ought to be positioned. Perhaps it is time to consider an *independent* National Park Service, on the model of the National Archives and Records Administration.[13] Over twenty years ago, the National

Archives was a part of the General Services Administration. It became apparent during the 1980s that the preservation of the national treasures managed by the National Archives—original copies of the Constitution, the Declaration of Independence, and the Gettysburg Address, to name only a few—within the General Services Administration was no longer in the best interests of those treasures or the American people. As an independent agency, the National Archives has been able to manage more effectively the records entrusted to its care. Independence for the National Park Service would enable it, like the National Archives, to focus more clearly on the mission of preserving its resources "unimpaired for future generations."

Independence alone, of course, would not solve all of the ills facing the Park Service. Along with independence, a more stable organizational structure could be attained by appointing the director of the National Park Service for a period of fifteen years, on the model of the Government Accountability Office. This model has served GAO, and the American people, well by preventing politics from influencing that agency's decision-making process. Following GAO's lead in this regard would also break the detrimental cycle of the NPS director tendering his or her resignation on January 20th upon the inauguration of a new administration. The combination of creating an independent National Park Service and appointing the director to a fifteen-year term would go far in diminishing the political interference reported in the *National Geographic* issue mentioned above. Moreover, the qualifications for the position of director need to be reconsidered so that only someone who can demonstrate a history of experience and excellence in all three of the Park Service's core—and co-dependent—functions of preservation, research, and education is nominated and confirmed.

One goal for the celebration of this now internationally recognized and respected federal agency created ninety years ago would be the clarification of the National Park Service mission through a "general authorities act" similar in concept to the one passed by Congress in 1970. This "National Park Service Centennial Act" would restate the grand role set forth for the agency in 1916, and project a future based on present realities. Such a centennial present would include language on biodiversity and ecosystems and the humanities and the fundamental role they play, through parks and programs, in the environmental and civic health of the nation. It would create an independent National Park Service with a director appointed for a fifteen-year term, and include a re-statement of the Park Service's core responsibilities.

A gift to the nation

What a gift this would be to the nation, to the citizens of this nation and to the future citizens of this nation! A professionally managed and adequately funded National Park Service and national park system—*publicly funded by the wealthiest nation in the world*—would affirm the highest ideals of those who championed the National Park Service cause one hundred years ago. From Yellowstone to Independence Hall, from the Everglades to Little Bighorn, the National Park Service administers the places that define this nation. The American people benefit from the preservation of these treasures whether they visit them or not. Countless citizens and communities profit from the conservation and preservation and educational activities of the National Park Service through its outreach programs. The National Park Service should not only be the leading preservation agency in the country, it should set the "gold standard" for the preservation of natural and cultural resources throughout the country and the world. The centennial of the National Park Service presents the nation with an opportunity to attend properly to the needs of an agency that preserves reminders of who we are as a people and where we want to go as a community.

How we mark this milestone—how we address the profound problems facing the National Park Service and how we strengthen the agency that contributes so much to our sense of place on earth and to our fundamental concepts of democracy and freedom and liberty—will reflect much about the American character. The centennial will either begin a renaissance for this most American of American institutions or it will pass, as so many centennials pass, with much fanfare and celebration signifying nothing more than the banal mediocrity which unfortunately we have come to accept from important national anniversaries. The path we choose will reflect the extent to which we cherish the remarkable cultural and environmental heritage values embodied within the national parks. The choice is ours.

Endnotes

1. James Bryce, "National Parks—The Need of the Future," in *Universal and Historical Addresses: Delivered During a Residence in the United States as Ambassador of Great Britain* (Freeport, N.Y.: Books for Libraries Press, 1968), 406. (First published in 1913.)
2. This is the first sentence of the National Park System Advisory Board's *Rethinking the National Parks for the 21st Century* (Washington, D.C.: National Geographic Society), 2001.
3. See Dwight T. Pitcaithley, "National Parks and Education: The First Twenty Years," for a short history of the role education played in the early years of the National Park Service. On-line at www.cr.nps.gov/history/resedu/education.htm.
4. *Rethinking the National Parks for the 21st Century*, 13–14.
5. Bernard DeVoto, "Let's Close the National Parks," *Harper's Magazine* (October 1953), 49–52.
6. See Richard West Sellars, *Preserving Nature in the National Parks: A History* (New Haven: Yale University Press), 1997.
7. Wallace Stegner, "The Best Idea We Ever Had," in *Marking the Sparrow's Fall: The Making of the American West*, ed. by Page Stegner (New York: Henry Holt & Co., 1998), 135–142.
8. See the Spring 2007 issue of the NPS magazine *Common Ground* for Director Bomar's vision for the National Park Service.
9. National Parks Omnibus Management Act of 1998 (Public Law 105-391). For an insightful analysis of the research authorization see David Harmon, "The New Research Mandate for America's National Park System: Where it Came From and What it Could Mean," *The George Wright Forum* (vol. 16, no. 1, 1999), 8–24.

10. Perhaps an even more analytical way of thinking about the centennial's budget is this: if one calculates the total budget for the decade between 1945 and 1955, one finds that the Mission 66 decade (the subsequent decade) represented a fourfold (411%, to be exact) increase from the previous decade. Thus, the 2006–2016 decade, if we were serious about properly funding the NPS for its centennial, might represent a 411% increase over the total for the previous decade of 1995 to 2005. In this case, the annual budget for the National Park Service from 2006 to 2016 should total $8 billion per year! (Thanks to Denis Galvin for helping me think through these numbers.)
11. Indeed, there seems to be a correlation between the rising price of park entrance fees and declining park visitation. Visitation to Yosemite National Park declined starting in 1997 after a steep price increase went into effect. Visitation during the decade prior to 1997 rose 41%. See "National Park Entry Fees Heading for Steep Hike: Tourism Officials and Western States Fight Proposal for Ongoing Increases." *San Jose* (California) *Mercury-News*, May 4, 2007. Between 1994 and 2001 nationwide, visitation to one hundred fee-demo parks declined by almost 2% while visitation to all other fee and non-fee parks increased over 20%. (Data gathering procedures changed in 2002, so current data does not provide reliable indicators for comparison.) See Department of the Interior, *Recreational Fee Demonstration Program: Progress Report to Congress, Fiscal Year 2001*.
12. Even with the best of intentions, interior secretaries can act counter to the best interests of the National Park Service. During the 1990s, Secretary Bruce Babbitt consolidated all of the Department of the Interior scientists into a new organization, which is now within the U.S. Geological Survey and titled the Biological Resources Discipline. Removing critical natural resource scientists from the Park Service may have made the Department's science program more efficient, but it was devastating to the long-term scientific programs in the national parks.
13. Unlike the Smithsonian Institution, another well-established independent federal agency, the National Archives and Records Administration is a completely publicly funded organization that reports directly to the president of the United States and does not employ a governing board of regents.

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Join the Centennial conversation!

Do you have a comment on the ideas presented in this essay? Ideas of your own to share? Whether it be criticism, praise, or something in between, we want to hear your thoughts on the National Park Service, its centennial, and the future of America's national park system. Write us at nps2016@georgewright.org and we'll post your comments on our Centennial webpage (www.georgewright.org/nps2016.html) and include a selection in the next issue of *The George Wright Forum.*

INTEGRATING SCIENCE AND MANAGEMENT

GUEST EDITORS: ALICE WONDRAK BIEL, ROBERT E. BENNETTS, BRUCE B. BINGHAM & ANDY HUBBARD

Integrating Science and Management: The Road to Rico-Chico

Bruce B. Bingham, Robert E. Bennetts, and Andy Hubbard

Introduction

THE VISION AND DIRECTION FOR SCIENCE-BASED MANAGEMENT OF NATURAL RESOURCES in the U.S. national parks was initiated with the National Park Service's Organic Act (1916), articulated by the National Parks Omnibus Management Act (1998), and formalized by the Natural Resource Challenge (1999). The progress and dedication to that vision we see in the NPS today would not be possible without the agency's critics, nor without the foresight and support of its leaders. Through new funding and staffing, the agency's Natural Resource Challenge formalized the Park Service's commitment to science-based stewardship of natural resources in the national parks.

To fully meet that commitment, we must take actions that facilitate and improve the integration of science, natural resource monitoring, and management decision-making. These actions should expand communication and collaboration by creating new partnerships between park managers and scientists. They should explicitly link NPS science programs and management in their objectives and processes.

If we are successful, what will emerge will be a new, innovative environment for learning, sharing, and applying new information and knowledge to management of the natural treasures protected by the National Park Service. Managers and scientists will integrate that information and knowledge—gained from research, monitoring, and management experimentation—to support relevant planning and informed decision-making about the resources entrusted to our care. Similarly, the experience and needs of managers will help guide research and monitoring efforts in parks. Together, scientists and managers will use adaptive concepts, strategies, and techniques to implement new knowledge in managing resources in accordance with the mission of the National Park Service.

The opportunity to strengthen the relationships between natural resource managers and scientists broadened with the funding of several initiatives included in the Natural Resource Challenge. One of these initiatives was the Inventory and Monitoring (I&M) program. The program is charged with developing and implementing long-term, park-based, natural resource monitoring of key indicators, or "vital signs," of ecosystem health. Vital signs monitoring is a crucial component in the NPS's strategy to provide scientific data and information needed for planning, management decision-making, and education. The program organized some 270 park units into 32 I&M networks. Each network links parks that share similar natural resource values. The networks promote a collaborative approach among parks to sharing resources and integrating science (e.g., resource inventories, monitoring, and research) and park management. This year, the Vital Signs Monitoring program received funding for all 32 networks, and the expectations for successfully integrating science and park management are greater than ever.

The Rico-Chico task team

The successful integration of natural resource monitoring and research information into park planning and management is critical to the continued relevance of the I&M program. With all 32 networks expected to be conducting vital signs monitoring by 2009, establishing a strategy and framework that explicitly links science and management—and strengthens collaboration for adaptively learning, sharing, and applying new information to park management—is becoming increasingly imperative.

In 2005, the Intermountain Region I&M networks initiated an effort to directly engage park managers, planners, and I&M staff and scientists to improve communication and strengthen the integration of science and management. We organized and hosted two workshops focused on improving the integration of research and monitoring information with natural resource management in parks. The first workshop, held in Rio Rico, Arizona, in December 2005, brought together park superintendents, resource program managers, and I&M staff and scientists to address the needs and expectations of managers for science-based decision-making. "Rio Rico," as the workshop came to be known, resulted in the formation of the Rico task team, an interdisciplinary group of managers and scientists assigned to begin work on a draft strategy and framework for improving the integration of science and park management within the Intermountain Region.

A second I&M workshop was held at Chico Hot Springs, Montana, in September 2006. The Chico workshop broadened the existing audience to include additional stakeholders important to the successful development and implementation of a framework integrating science and management. Participants included park superintendents, resource managers, regional planning staff, and staff from research learning centers, cooperative ecosystem studies units, regional offices, the Washington office, and other partners.

At Chico, the Rico task team presented a draft outline of a strategy and framework focused on several themes important to successfully integrating science and management. The Chico workshop included exercises that actively engaged managers and scientists in an adaptive process of integrating science and management. Using real management issues and monitoring data, management needs were discussed and incorporated into vital signs monitoring, and monitoring and research information was brought into management decision-making processes. In short, managers and scientists discussed resource management issues and objectives as well as research and monitoring results, and adaptively applied their newly gained knowledge to solving problems. The Chico workshop produced a broadened group of committed managers and scientists, called the Rico-Chico task team, who were assigned to expand and refine the strategy and framework for improving the integration of science and park management.

The framework

The Rico-Chico task team has introduced a strategy and framework that incorporates three themes for integrating science and management: (1) improving communication, (2) incorporating management needs into ecological monitoring, and (3) incorporating monitoring results into management and planning. The strategy promotes communication and information exchange between scientists and managers through workshops, thematic meetings, and consultation. Products include web-based resources, professional and technical reports, concept papers, and publications such as those presented in this issue of *The George Wright Forum*.

Improving communication

Communication is at the center of the framework. The other two themes are inherently dependent on developing and maintaining open communication based on mutual trust and benefit. While NPS scientists and managers may differ in their motives, the passion they share for the resources they study and manage binds them to the same mission and goals. Nevertheless, scientists and managers often find that they use the same terms differently—and different terms similarly—when conveying concepts that are basic to their respective positions. As will be evident from some of the papers in this issue of the *Forum*, communication barriers between scientists and managers have hindered, and continue to hinder, our ability to integrate science and management. With that in mind, the task team identified the following statement as its integration goal for this theme: *"to improve communication and the sharing of knowledge between science and management."* The paper by Carter et al. in this issue addresses some of the emerging tools and ideas that will better facilitate communication between scientists and managers.

Incorporating management needs into ecological monitoring

Too often, managers and scientists find themselves competing for the same limited resources. When the I&M networks were created and funded through new appropriations, we moved from an environment of competition to one of sharing resources for mutual benefit. In the National Park Service, the opportunities for scientists and managers to work together have never been greater. The integration goal for this theme identified by the task team—"*to incorporate the knowledge gained from resource management experiences, and information needs of management and planning into the design and implementation of our ecological monitoring*"—is more feasible now than ever before. The paper by Carter and Bennetts begins to explore how a hierarchy of goals and objectives can be used to reinforce the assimilation of monitoring and park planning. The paper by Hubbard et al. addresses the need to integrate goals and objectives for natural and cultural resource planning when prioritizing management and monitoring needs. The essay by Lewis highlights the real challenges faced by managers when trying to balance political and socioeconomic interests and concerns with what the science is telling them.

Incorporating monitoring results into management and planning

Prior to the Natural Resource Challenge, most park managers who wanted to acquire science-based information for decision-making purposes had no other avenue but to try and entice researchers from universities and other agencies to conduct studies in their parks. However, once the research was completed and the results in hand, ideas about how to apply the new information were too often an afterthought. Because the I&M program designs its research and monitoring efforts with direct input from park managers, the results are more readily of use to managers, facilitating this theme's integration goal of *incorporating the knowledge gained through science, including research and monitoring, into park resource planning, management, and decision processes*. The I&M monitoring program is new, and figuring out how best to apply our monitoring methods and incorporate the results into management decisions will take some time, creativity, and even experimentation. The paper by Bennetts et al. explores the merits of using assessment points as a means of allowing monitoring data to inform management and planning. The essay by Marcot discusses assessment tools and methods for aiding scientists and managers in analyzing uncertainty and risk in decision-making.

Vital signs monitoring is also expected to provide park managers with measures of performance in regard to long-term management goals. Working with planners and managers, we will more closely link vital signs to management goals, such that monitoring data will inform managers about the condition and trend of key resources in the context of long-term desired outcomes. The effectiveness of near-term strategies and actions at producing desired outcomes likely will require additional information, possibly from new research and other types of monitoring. The essay by Bingham highlights potential information-management barriers and solutions to integrating existing and new research, monitoring, and management information across agencies and programs. The paper by Bennetts and Bingham expresses some concerns that have emerged about the efficacy—and even fairness—of using monitoring results related to resource condition to provide accountability for management performance.

The challenge continues

The essays and papers presented in this issue of the *Forum* represent some of the results of the Rio Rico and Chico Hot Springs workshops, and the efforts of the Rico-Chico task team. We are grateful to the George Wright Society for the opportunity to present these results and ideas. However, we fully recognize that significant effort and accomplishments are occurring throughout the NPS, at all levels in the organization, and in other agencies and organizations as well. The Rico-Chico effort is just one small part of a much larger movement within the

National Park Service and other agencies and organizations to bring science and management into closer partnership.

In his essay on integrating science and management, Soukup captures what the National Park Service must become to achieve the vision initiated nearly a century ago with the Organic Act. The NPS is fortunate to have visionaries and doers at all levels, from our leadership to our professionals completing projects in the field. The Natural Resource Challenge generated momentum, but it is our people that keep us moving forward. They all contribute to emerging, evolving ideas about improving the integration of natural resources science and management. Although the authors listed here have tried to capture some of these emerging ideas, the ideas themselves have emerged in no small way from the Rico-Chico workshops and many discussions with others far too numerous to name. We appreciated the enthusiasm expressed by participants in these workshops and discussions, and we recognize that transforming these concepts into workable solutions will require continued effort by all of us. We also recognize that the goals we have outlined and are striving to achieve will not be reached overnight. The "challenge" continues, and working toward better integration of science and management is going to be a long-term commitment. We are confident that the dedicated individuals working to protect our natural and heritage resources are up to the challenge.

Acknowledgments

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Integrating Science and Management: Becoming Who We Thought We Were

Michael Soukup

Anyone who spends time implementing the National Park Service's Organic Act becomes impressed with its inherent technical challenges. If we are to keep parks unimpaired, we will have to understand large-scale issues, such as fragmentation of landscapes surrounding parks, the high-stakes losses that invasive plants and animals promise, the decline in migratory species, and the all-pervasive implications of global climate change, in sufficient detail to manage them. While intuitive decision-making may have sufficed in the 20th century, it certainly will not ensure that the natural systems (the "wild life and scenery") of national parks will be maintained throughout the 21st century. In that sense, the Organic Act drives us toward mastery of natural systems science, toward understanding, and toward action. We have no choice.

Meeting that challenge requires that a lot more information be generated, synthesized, and applied in parks. It is not enough to conduct issue-driven science in our national parks; we must find better ways of incorporating a broad, science-based understanding of the dynamics of our resources into our planning, decisions, actions, and messages.

Though much of that may seem clear today, National Park Service managers were roundly criticized in the latter third of the 20th century for viewing science "with anything from benign neglect to outright hostility" (Kaiser 2000). The National Park System Advisory Board, in its 2001 report *Rethinking the National Parks for the 21st Century*, noted: "Debate over the lack of science-based resource management continued [since the publication of the Leopold Report in 1963], but the Park Service made little progress during the last three decades in acquiring solid knowledge about park resources. Though criticism for this omission has mounted, science still takes a back seat in the parks."

The lack of progress noted by the Advisory Board in 2001 was symptomatic of a larger reality: for most of its history, the NPS has suffered from a predictable schism of dealing with the comfortable and familiar realm of visitor services (to satisfy the public and Congress) versus investing in science and scientists to deal with looming, large-scale, impairment-level resource threats. For decades, the need for science in park management was more a source of denial than an accepted truth. In the past, we appeared to be doing better than we actually were—an endemic problem in an agency whose spectacular resources can hardly help but make their managers look good. In short, we were wearing the white hat—but there was something missing underneath. There existed a monumental gap between what the NPS thought it was, and what it had to do to become what it needed (needs) to be.

Toward the end of the 20th century, the need for science to underpin management—and the lack of it—was becoming achingly clear. The National Environmental Policy Act (NEPA), and the public at large, demanded greater accountability from NPS decision-makers. Full disclosure of proposed action alternatives, and the environmental consequences thereof, often tended to expose how much we didn't know. Significant court decisions faulted the agency for failing to base its actions in sound science. But ambivalence remained, in part because science was not originally built into the culture of the agency, and also because of a lingering sense that natural systems only had to be within a park boundary to be protected, or were so complex as to be unknowable, anyway.

So, what do we have to do? I recently heard of visitors from Germany observing that we treat environmental compliance like the icing on a cake, while they treat it as part of the batter. I think that analogy also applies to science in parks. The Natural Resource Challenge may be a turning point towards operational integration of science throughout the organization. At least I hope so.

Quite possibly, a change in attitudes among upper management began to crystallize with the publication of *Preserving Nature in the National Parks* (Sellars 1997.) In fact, a number of factors aligned to produce the group effort that became the Natural Resource Challenge. Funded by Congress since 2000, the Natural Resource Challenge brings science (resource inventories, monitoring, and applied research) and many science-trained personnel back into 271 natural resource parks. It provided the NPS with a vision and strategy, built around several on-going and some new initiatives, to improve the integration of science, park planning, and management. The goal was to revitalize and expand the natural resource program within the Park Service and improve park management through greater reliance on scientific knowledge. The Natural Resource Challenge was, and is, a challenge to everyone in NPS—not just a few—to use science, to depend on it in decision-making, and to make it an unquestionable part of park operations. The Natural Resource Challenge is our statement and a commitment that we will prepare to meet an uncertain future head on.

But ecological monitoring data and research reports do not, in themselves, improve stewardship of park natural resources. Scientific information must be accessible and integrated into planning, environmental compliance, interpretation, and resource management. Based on the experience of the NPS and similar efforts by other agencies, this incorporation of new information may be the most daunting and important step.

Historically, one hurdle in the path of integrating science and park management has been that the science produced by researchers in national parks is not always immediately relevant to current management needs. As such, finding relevant science often has been an opportunistic process for managers, in which their information needs are fulfilled—or not—based on what happens to be available. Or if funding can be found, the results appear several years down the road, often after decisions have been made. For those who hope that their science may result in an improved national park system, this disconnect isn't optimal either, as it relegates a wealth of otherwise useful scientific information to a shelf in a manager's office.

The real answer, in my opinion, lies in a fundamental change in our approach to and attitudes toward science in parks. First, we must transform parks into true laboratories—vibrant hubs of discovery. If parks become the first choice among potential research sites for a broad spectrum of field scientists, a wealth of information can be accumulated. Very little may be of immediate use, but each park that invests in the role of research venue as a larger, legitimate part of park operations will become information-rich.

However, parks must then take a second, critical step. Parks also must invest in the long-term presence of systems modelers and integrators, whose job it is will be to assemble the accumulating wealth of data into functional models that identify structure, quantify relationships, and eventually allow predictions. Constant refinement of these models over time will evolve into a broad understanding of the complexity of park resources—fortifying the NPS's position as the credible authority on NPS resources. When this happens—and there are examples of parks where it has—parks becomes the decisive voice for park protection in all the important arenas (public, legal, congressional, media). Combined with an effective education program, parks can influence not only park issues but also larger quality-of-life issues in their surrounding communities and contribute significantly to the environmental health of the nation. This was the underpinning concept for the Research Learning Center Network, which has not yet been developed to its potential. This investment by parks would truly represent a major shift in how managers approach protecting parks.

Both managers and scientists must shift how they see themselves and each other, as well. First, they must recognize they are partners, for only in an environment where scientists and managers share a common vision of the outcomes of their respective efforts can we truly expect an effective integration of science and management. To those ends, the National Park Service can:

- Meet the needs of park visitors, but also invest heavily in becoming the world's authority on park resources.
- Encourage academics (and their funding organizations) to see parks as places to do work and to see their research incorporated in usable knowledge that is used directly for the public good.
- Train managers to move toward a true integration of science and management by developing personnel who are long-term, on-site authorities on park resources.
- Establish processes that enable managers and scientists to interact and communicate in ways that meets the needs of park managers and preserve the independence and integrity of its scientists.

A workable analogy might be an operational protocol that gives to a senior park ecologist or science advisor the same deference that is traditionally given to a trusted solicitor. This is vital if one accepts that each bad environmental decision has an accumulating impact perhaps at least equal to legally problematic ones. If we are serious about maintaining the quality of a national park experience, we must minimize our error rate.

In sum, the future for national parks will be bright if parks are seen by the scientific community as optimal research sites. At the same time, the future can only be bright if we have a full and serviceable understanding of complex park resources. We must choose new priorities in operational funding and in mission-relevant organizational principles. We must not guard our past practices; we must guard the long-term viability of parks. Otherwise, we will gradually lose the wild, authentic qualities of our parks as the cumulative result of unreliable decision-making. We must do whatever it takes to achieve the outcome intended by the Organic Act. That includes mastery of natural systems science and its application. We can become the agency we thought we were, and always wanted to be.

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The Quandaries and Promise of Risk Management: A Scientist's Perspective on Integration of Science and Management

Bruce G. Marcot

THE TEXTBOOKS ON RISK MANAGEMENT ARE WRONG ... OR IMMENSELY NAÏVE.

Traditional risk analysis, such as through the use of decision trees, entails depicting (1) a set of alternative decisions or decision pathways based on a specified risk attitude of the decision-maker, (2) the response of the system of interest and associated probabilities, and (3) values (or utilities) of each outcome and expected values of each possible decision. Best decisions are then identified as those with the lowest expected cost or highest expected benefit values.

For two decades, I have worked in risk analysis on both sides of the management/research fence in a federal land-management agency in areas of wildlife and ecosystem conservation (e.g., Marcot et al. 2006). I can attest that this classical risk-management framework, as applied to public land and natural resource management, just doesn't work as portrayed in the textbooks. Here's why, and here are some practical opportunities for more successfully integrating science and management in this arena.

The roadblocks to risk analysis and risk management

First, alternative decisions are seldom discrete, exclusive, independent, and identified *a priori*, as assumed in risk-analysis methods. Rather, decisions are often defined and made in combination, are dependent on other decisions, and are made only after initial social reactions or environmental outcomes are ascertained.

Second, what is "at risk" in risk management often means very different things to scientists and managers. Scientists might craft a risk analysis to predict the likelihood of viability of an endangered species, for example, whereas a manager might (legitimately) consider political fallout, social response, or opportunities for future funding to be what is at risk.

Third, scientists and managers are usually willing to accept different degrees and types of uncertainty. Uncertainty is one hallmark of scientific expression, but managers—like politicians, the press, the courts, and the public—often want clear, unambiguous answers. To scientists, the scientific method imposes the burden of proof of some effect (such as a management decision on a fragile ecosystem or species) on falsification of null hypotheses stated as no effect, whereas managers may impose the burden of proof on definitive evidence that there *is* such an effect. To some managers, absence of evidence is evidence of absence (or of no adverse effect from management activities), whereas under the scientific method, absence of falsification of the null hypothesis does *not* constitute evidence of no effect.

Fourth, the values (or utilities) of each outcome can be measured and interpreted in vastly different ways and often are not independent, as assumed in risk-analysis models. Utilities also typically exclude externalities and indirect pecuniary costs and effects. There are major problems in quantifying non-economic social costs and benefits in parity with economic ones, and most risk-analysis methods cannot combine unlike units of measure of utilities such as dollars and psychological satisfaction ratings.

Fifth, managers seldom articulate their decision criteria—especially prior to making a decision—perhaps, in part, out of understandable reluctance to reveal their personal values and attitude toward risk. Equally so, modelers seldom articulate the major assumptions and weaknesses of their risk-analysis models—which may similarly reflect a modeler's risk attitudes and personal values and biases—and seldom explicitly test how such assumptions affect model performance, outcomes, and interpretations.

Sixth, managers seldom disclose or even know their own risk attitudes, and seldom attempt to determine them through rigorous methods, although best or optimal decisions can vary greatly under different risk attitudes. Further, managers might not adjust their risk attitude to better match that of the public they serve, in part because the risk attitude of the public is also often unknown or is highly diverse and quite variable among interest groups.

Seventh, estimates of probabilities of outcomes for a given management decision are seldom validated by the risk modeler or corrected with monitoring data. Managers are often reluctant to incorporate monitoring as an integral element in decisions, more typically tacking monitoring tasks and objectives onto the end of a decision—and only if funding and political expediency permit.

Finally, expert knowledge compiled to parameterize a risk-assessment model can be biased, incomplete, contradictory, and just plain faulty. Most risk-analysis models entail at least some use of expert opinion. However, expert understanding, such as of ecosystems and sensitive species, often is rudimentary. Compounding of variables, propagation of error, and non-linear or chaotic behavior of systems can be nearly impossible to calculate and predict with any accuracy but can greatly affect the magnitude and direction of outcomes.

Some ways around the roadblocks

So what are the scientists (risk modelers, risk analyzers) and managers (decision-makers) to do? Here are some suggestions for removing the roadblocks and helping scientists and managers to better communicate.

In recent years, a number of new, structured, decision-aiding tools and methods have been developed (e.g., Lynam et al. 2002) that ease some of the strict assumptions of traditional risk-analysis modeling approaches. For example, several formal methods can efficiently address multi-objective decision-making, such as multi-attribute utility theory (MAUT; Merkhofer et al. 1997), goal and analytic hierarchy process (AHP; Vargas 1990), multiple-criteria decision-making (MCDM; Mendoza and Prabhu 2000), and others. Most of these approaches are relatively simple and entail a general process of articulating objectives, identifying criteria for rating each objective, listing alternative possible decisions, quantifying performance levels for each combination of decision and objective, quantifying or weighting preferences (priorities) for each objective, ranking the alternative decisions by potential outcomes, and doing sensitivity analysis of the decisions by altering weights or criteria. The goal and analytic hierarchy procedures follow a similar approach by prioritizing objectives, estimating probabilities of various alternative decisions meeting the objectives, and filtering out decisions that have unacceptably low probabilities, given risk-attitude criteria of acceptability. Another value to such approaches is that they are able to effectively incorporate adaptive learning and monitoring information (Holz et al. 2006).

Following such rigorous decision-assessment techniques can also bring clarity to issues of mixed interpretations in regard to what is deemed to be "at risk," and of how utilities and values of decision outcomes are depicted (Ohlson and Serveiss 2007). The new methods also can deal with the problem of disparate units of measure among different utility outcomes, and can help to structure clear articulation of decision criteria, risk attitudes, and model assumptions.

Other methods have been developed to rigorously solicit and depict expert knowledge in a repeatable and defensible manner, so that expert knowledge is not viewed as arbitrary personal opinion (Newberry 1994). Such techniques date to the early 1980s, with the emergence of classic expert systems in artificial-intelligence research, in which "knowledge engineering" methods were developed to capture knowledge of an expert in some domain. Similar approaches, such as the Delphi paneling process (MacMillan and Marshall 2006), can be used to rigorously compile knowledge and opinion from a group of experts (also see Geneletti 2005). Related methods can rigorously incorporate opinions of stakeholders to help define management objectives and indicators (Lahdelma et al. 2000).

Managers are becoming more adept at dealing with risk-analysis answers stated in terms of probabilities of outcomes. Bayesian risk-modeling approaches are now popular ways to depict decision outcomes as probabilities (Steventon et al. 2006). Still, scientists can do better to educate non-scientists on the scientific method, hypothesis testing, implications of scientific and prediction uncertainties, and ramifications of various types of errors (e.g., false positives and false negatives).

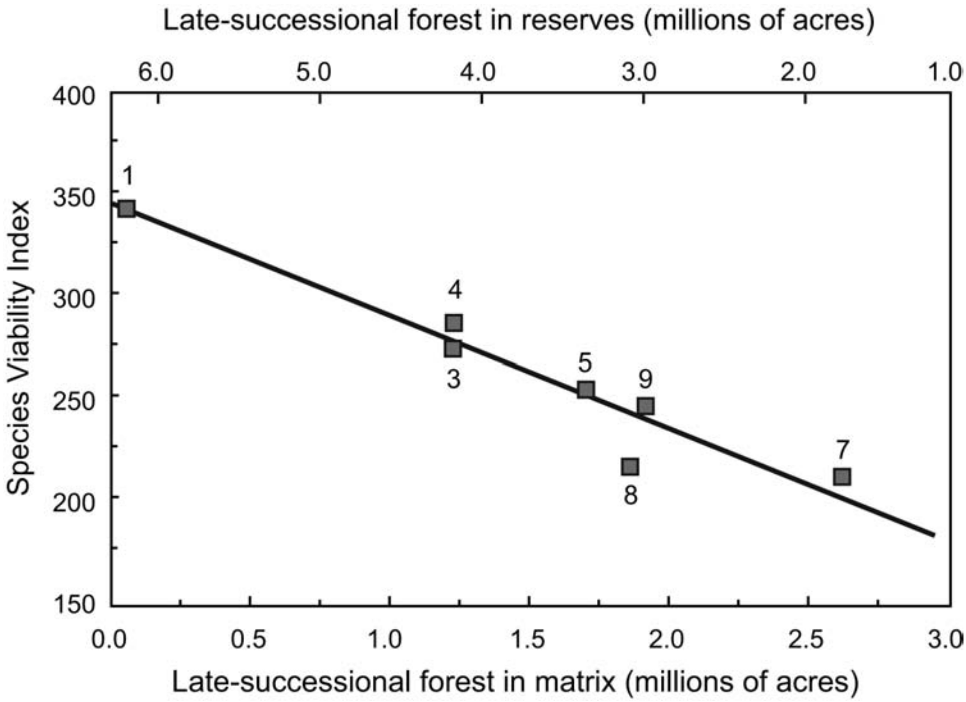
However, not much progress has been made, in the decision-analysis realm, on solving problems of covariance of variables, propagation of error, and erratic behavior of complex systems. The best approach to dealing with such messy problems is to decompose the problem set into modules or more-focused subsets of the problem using hierarchy theory (Ratzé et al. 2007), and build simpler, stepwise evaluations of the decision pathway. A complementary approach may be for the manager to consider the outcome of some similar problem already addressed, whether adequately solved or not. Other heuristic problem-solving tricks (e.g., Polya 1973) can be used to help guide difficult decisions.

Another, and perhaps the best, approach may be to consider some intractable problem from an entirely new perspective. An example might be trying to find some perfect balance between conservation of old-growth forests for northern spotted owls and exploitation of those forests for timber and other wood products. There may be no single solution that simultaneously satisfies risk attitudes of decision-makers, all public interests, legal mandates, and conservation objectives. Instead of viewing the problem as a zero-sum game with trade-offs, a more useful approach may entail breaking down the problem by geographic area, forest type, and land ownership, and then considering how to increase conservation without sacrificing other forest uses, or increase forest use without threatening conservation (Figure 1).

Finally, scientists and managers alike can make the best progress by incorporating learning into their risk analyses and risk decisions (McDaniels and Gregory 2004). Scientists can monitor changes in the system and incorporate new understanding, probabilities of outcomes, and unforeseen events into their analyses. Managers can view decisions as learning opportunities by stating them as testable hypotheses and working with researchers to phrase the tests in a scientifically correct manner.

The future is bright for applying new decision-assessment tools for aiding risk management. Perhaps the most important

Figure 1. A typical trade-off scenario depicting lower expected viability of wildlife species associated with late-successional forests (Y-axis) with increasing amount of that forest open to timber harvest in the "matrix" (lower X-axis) or with decreasing amount in reserves (upper X-axis). Shown are expected effects of seven planning alternatives (a modification of alternative 9 was eventually chosen as the basis for the Northwest Forest Plan in the Pacific Northwest, U.S.). Instead of viewing this relation as a zero-sum trade-off, however, the resourceful manager might explore how higher viability levels could be achieved from the same level of timber base (or forest reserves), such as comparing alternatives 4 and 3, and 9 and 8, which differ in their conservation guidelines. Source: FEMAT 1993.



decision to be made for true success will be for scientists and managers alike to commit to working together in a setting of honesty, openness, and mutual learning (Roux et al. 2006).

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The Role of Science in National Park Service Decision-making

Suzanne Lewis

In these challenging times, when allocations to parks are not increasing at a rate commensurate with costs, park managers are faced with difficult decisions about park priorities and staffing: which programs are going to grow, which are going to remain flat, which are going to be downsized, or even disappear? We also are making choices about resources and visitor-use issues in a complex context, and often in a divisive atmosphere. By mandate and necessity, science is a part of the decision-making equation. As decision-makers, our jobs are made much easier, and the results are better, when the science is relevant, readily available, and clearly communicated.

In keeping with the times, then, this essay addresses four key areas relating to the intersection of science and management in National Park Service units: the role of science in park decisions; science successes and science stalls in the National Park Service; the differences between science and resource management, and how to improve the way they work together; and, finally, the art of communicating science to park managers. These comments should be taken for what they are: a combination of information and advice, from a park manager's perspective, challenging scientists to keep working hard, keep getting better, and keep focusing their efforts on science that makes a difference to decision-makers in parks.

The role of science in park management

First, what role does science play in park management—in helping a superintendent to make decisions about park resources and issues? Science—even good science—does not replace good decision-making. Science is an important and even critical input into decision-making. Science helps us to decide where to focus our efforts. For instance, in the winter-use debate that has been going on in Yellowstone for almost 20 years, natural resource monitoring has helped us to determine that snowmobiling has greater impacts on air quality and the natural-sound environment than on water quality and wildlife populations.

Science also helps us to set reasonable thresholds for change, and tells us when we are close to those thresholds. The state of Wyoming, for example, has established a threshold of allowing no more than a 10-NTU (nephelometric turbidity unit) increase in sediment in Outstanding Natural Resource Waters. Science helps us to determine trends, and helps us to set priorities for resource programs. In Yellowstone, we have been counting fewer and fewer Yellowstone cutthroat trout (YCT) spawners in Yellowstone Lake. As a result, we have intensified our lake trout control efforts and begun to search for stream reaches where we might begin restoring populations of native YCT.

But scientific information is only one input into management decisions. As a park manager, I have to balance many issues and interests in every decision I make. Most of those issues and interests are based on values, rather than quantitative information. At the end of the day, I will never have all of the information I need to make a decision. I often have to do what Malcolm Gladwell, in his book *Blink*, calls "thin slicing": take a small amount of information, often just an impression, and make a quick decision. Having access to better information can mean making a better-supported decision. But I still have to weigh all of the information, including the science, and use my best judgment.

Science successes and science stalls

Second, what are our science successes, and where has our science stalled? In the National Park Service, our successes tend to be in the biological and physical sciences. In Yellowstone, an incredible network of scientists—at least 211, based on the number of research permits the park issues—gathers information about the park. There are scientists studying wolves, grizzly bears, elk, pronghorn, and bighorn sheep. Scientists study fire behavior and fire ecology. They study rare plants, exotic plants, willows, aspen, and whitebark pine. Twenty-two seismic stations and 12 GPS leveling stations help more than a dozen scientists to monitor the Yellowstone Volcano.

More than 40 microbiologists study the thermophiles in hot springs, for purposes ranging from cataloguing the life they find to trying to understand life on Mars. Scientists study fish; they monitor air and water quality. There's even a researcher studying the fungi in mammal scat. Based on all of this science, researchers have provided us with a reasonably clear picture of the status and trend of many of Yellowstone's highest-priority resources, and they have developed a context for identifying which biological and physical resources are most important to monitor. In fact, the Greater Yellowstone Inventory and Monitoring (I&M) Network's vital-signs development process, which engaged more than 250 scientists over a three-year period, has been instrumental in helping park managers decide what to monitor.

However, the most controversial and important decisions I make, as a superintendent, turn as much on people's values as on biology, geology, or ecology. In the case of winter use, for example, resource impacts are important, but the primary decision to be made is based on a value question: Are snowmobiles a proper mode of transportation for a national park? The same is true of bison management, wolf restoration, grizzly bear recovery—even the question of where and when we ought to enable people to use cell phones in Yellowstone. These questions are all about values.

Then there's the question of social science. In the National Park Service, we simply do not have the kind of science firepower in the social sciences that we do in the biological and physical sciences. In Yellowstone, in 2006, of 211 research permits, only three were for social science studies: that's 1.4%. There are simply not enough people out there helping us to understand our visitors. And yet we need that kind of information. The kinds of decisions I make as a superintendent every day demand it. Social scientists are equipped to give meaningful input into the values-based issues that we face. That input seems to be largely missing from the national parks, especially as it relates to value-based issues involving natural resources. Social science is our biggest "science stall." A stall that we cannot afford to let go on unaddressed.

Science and resource management

Third, although we do both in the national parks, there is a distinction between resource management and science. Resource management is roll-up-your-sleeves, get-down-in-the-dirt work. It needs to be informed by science, but is more oriented toward on-the-ground results, and often guided more by experience or intuition than by science. For example, controlling exotic plants is not science. It is typical of the work done in resource management: sweltering on a hot summer day in a Tyvek suit, mixing tanks of herbicide, walking along roadsides, and spot-spraying weeds. But knowing which herbicide to mix for which weed is the result of science—science that comes to us through private industries, universities, and the cooperative ecosystem studies units, as well as our own staff.

Science helps to improve the resource management performed in parks. Managing bison—hazing, capturing, shipping, holding—is not science. It is simply hard work, done by dedicated park rangers and resource staff in the bitter cold of winter, in the deep snows of West Yellowstone, the biting winds of Stephens Creek. Science—ecological monitoring, monitoring travel routes, and development of better vaccines and delivery systems—informs what we do and how we do it. Science especially helps us to come up with good adaptive management strategies.

Lake trout control—setting and pulling 13 miles of gill nets each week in Yellowstone Lake: not science. In fact, it can be backbreaking labor. It is dirty, smelly work, pulling fish that have been dead for almost a week from nets. Where science intersects with lake-trout control is in determining the best places and types of nets to set to catch the most lake trout with the least bycatch of Yellowstone cutthroat trout. Our staff is also working with outside scientists to determine how effective the program has been, to create models that predict where we will find new spawning areas, and to develop better methods of monitoring the population of YCT in the lake. Again, we adapt our program as we acquire new scientific information.

One of the challenges faced by scientists is translating discoveries into procedures and practices that can be implemented by resource managers—people who are not necessarily scientists. That is where the rubber meets the road in most parks. To be relevant to managers, scientists should always ask themselves: How can resource managers use the information that I am discovering? How can they use it in adaptive management? How can they use it to increase the focus and effectiveness of their programs? How can they use it to evaluate their programs, many of which are at least based partly on intuition?

The art of communication

Finally, none of these things are possible without good communication between scientists and managers. As a superintendent, I sometimes feel a bit like Mark Twain, who famously quipped, "Researchers have already cast much darkness on the subject, and if they continue their investigations, we shall soon know nothing at all about it." Think about it: the first thing scientists do, when they go to school to become scientists—no matter what field they go into—is learn a specialized language. This language helps them to communicate with other scientists in the field, but it does not help them to communicate with anyone else.

For instance, the gold standard for written science communication is the peer-reviewed manuscript—again, good for other scientists, not so good for the rest of us. The results of a survey recently published in the journal *Science* found that managers only used journal articles to gain information about 2% of the time. Again, necessary for scientific credentials, but not an ideal communication tool.

Finally, scientists tend to know (and communicate) too much. As a manager, my job requires that I be like the Mississippi River: a mile wide and an inch deep. There are simply too many issues on the table for me to be able to focus too deeply on just one. I read a lot of technical reports and scientific articles on the resource issues I am personally involved in, the ones with high complexity and high stakes: bison management, winter use, road construction. For everything else, I need the Cliff's Notes version as a primer.

Here are some pointers for communicating scientific information to the superintendent:

- **Use plain language.** If someone outside your area of expertise is not likely to understand a word, explain it. Or choose a more common word.
- **A picture is worth a thousand words.** Sometimes I just need to see it. That doesn't mean just charts and graphs. Real pictures, or at least good graphics that depict the situation, are always helpful.
- **Keep it short!** Synthesize. Explain what you know in 4–5 bullets. You might know more than anyone else in the world about the tapeworms in Yellowstone Lake, but I can't afford to. It is actually harder work to boil things down to a few bullets than it is to tell the "rest of the story." Do the work; the rewards, as far as communication, will be great.

On a final note, there are six principles of influence I have used successfully when trying to communicate and influence others. They also tend to work when others are trying to influence me:

- **Reciprocation.** Simply put, that means, You, then me, then you, then me. Or, put another way, it means you should be the first to give service, information, and concessions.
- **Scarcity.** The Rule of Rare. Simply emphasize genuine scarcity, share unique features, and always provide exclusive information.
- **Authority.** Showing is knowing. Establish your position through professionalism, industry knowledge, your credentials, and always admitting weakness first.
- **Commitment.** Always the place to begin. Start small and build over time. Where possible, start with emphasiz-

ing existing commitments, start from "public" positions (not personal ones), and start with what are voluntary choices, not mandates.

- **Consensus.** People proof and people power. Unleash that power by showing responses of many others (not just your own), sharing the past successes of others, and providing testimonials of similar others who share your views.
- **Liking.** Making friends to influence others. Uncover similarities between you and who you are hoping to influence, finds areas to provide genuine compliments, and always seek opportunities for cooperation and collaboration.

Case studies—yes, social science studies—have proven that these principles can and do work, but mostly they are just a good, common-sense approach to communicating needs in order to influence others. We, managers and scientists, have to make sure that we are working in sync and communicating well. The costs of failing to integrate science and management are simply too high.

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Information Management: Barrier or Bridge to Integrating Natural Resources Science and Management?

Bruce B. Bingham

Introduction

Over the last century, federal land-management and regulatory agencies have amassed tremendous amounts of natural resources data. Next to the vast natural resources on public lands, information is perhaps the greatest public asset managed by these agencies. The potential value of these data to managers and scientists is well appreciated, but not always well received. That is, we are often aware of the information and anticipate its value and utility to addressing a particular management, monitoring, or research need, only to encounter unanticipated barriers related to how the information may have been collected, documented, or managed. Historically, agencies have committed funds and effort to data collection that far surpassed those allocated to data management. However, over the past decade, agencies have been changing this practice and now obligate significant resources to information management. Agencies are behaving more like corporations by applying business-driven, or "enterprise," concepts and principles to information management. Enterprise solutions are those that facilitate the communication and exchange of information throughout an entire organization, including among functions, divisions, or other components. The concepts are applied through information technologies and architectures (hardware, software, and data models that are typically structured in a top-down hierarchy), that enhance an agency's ability to share information, integrate systems, reduce costs, increase productivity, and improve data quality. At the federal departmental level (e.g., Interior, Agriculture, and Commerce), commitments to supporting enterprise information architectures have been substantial.[1] Nevertheless, challenges and frustrations continue to hinder efforts to share data across projects, programs, and agencies.

In this essay, I will describe a range of information-management barriers that continue to obstruct basic efforts to integrate science-based information with natural resource monitoring, planning, and management. I will also propose some solutions to those barriers. Some of the barriers can be bridged with minimal time and effort by applying appropriate technology and funding; others may be too costly to bridge. The existing information-management infrastructures and systems unique to each agency—and often among programs within agencies—present significant challenges to information sharing, but can be resolved. Other barriers are deeply ingrained in human attitudes and agency cultures and may take as many decades to change as it took to amass the vast amounts of data at hand. The natural resource data collected through research, monitoring, management, and planning should be available across disciplines, programs, and agencies for analysis, synthesis, and application to management challenges.

Background

The basis for my observations comes largely from my experience working with long-term natural resources monitoring programs, particularly the Interagency Effectiveness Monitoring Program for the U.S. Forest Service's and Bureau of Land Management's Northwest Forest Plan. This was a comprehensive, broad-scale, 100-year land resource management plan, with the long-term goal of sustaining resources related to mature and old-growth forests, as well as resource-reliant economies within the range of the northern spotted owl. The agencies cooperating on the plan recognized the need for an effectiveness-monitoring strategy, and targeted the first analysis of the overall effectiveness of the Northwest Forest Plan for 2004, 10 years after the plan was implemented. The results presented in the 10-year interpretive report would be used to adaptively adjust management strategies and make adjustments to the monitoring program.

Requirements analysis

Long-term monitoring and analysis relies on a wide range of internal (collected directly by the monitoring program) and external (collected by other programs) data and information sources. When I joined the effectiveness-monitoring program in 2001, I initiated a requirements analysis to identify internal and external existing data and new information needed for the 10-year interpretive report. Generally, the process focuses on analyzing the strategic business and functional information needs of a program. The result should be a clear understanding of the required data, data models, analysis applications, software, hardware, connectivity, and standard operating procedures for information management.

Because of time and resource constraints, the effort focused on documenting the functional needs of the monitoring program in the context of the 10-year interpretive report. The analysis included documenting the monitoring objectives and questions; identifying required data attributes, including scale and resolution; describing the summarization or analysis of the data; and discovering existing data sources. The specific steps followed were:

- **Document the questions that need to be answered.** What are the monitoring questions related to each indicator? What other questions will be addressed by the monitoring program (e.g., questions centering around implementation, resource outputs, and expectations)?
- **Identify attribute-specific information or data needs.** What types of data are needed to answer the monitoring questions? What are the required attributes of the data?
- **Determine the scope, scale, and resolution requirements of the analysis.** What are the required temporal and spatial scales of the analyses? What are the required temporal and spatial resolutions of the data?
- **Understand the data-processing needs.** What new data models are required? What analysis applications are required?

- **Estimate the effort required to acquire existing candidate data.** Where is the information located? Can the required information be obtained?

Throughout the process, I tracked issues that emerged at each step and documented them in a data-issues log. For each potential data source, this documentation included a statement of the issues, the affected operations, potential impacts on completing the 10-year interpretive report, and recommendations for addressing the issues. Once documented, the issue statement was assigned a number and logged for tracking and resolution.

Categories of barriers

By February 2003, the requirements analysis had identified 110 data sources needed by the monitoring program. Fifty-four of these datasets were determined to be critical to producing the 10-year interpretive report. Analysis of the information recorded in the issue-tracking log revealed several categories of issues that presented significant barriers to integrating datasets and other information critical to evaluating the effectiveness of the Northwest Forest Plan:

- **Existence.** The data were believed to exist but could not be located, or were so incomplete that for all practical purposes, they were nonexistent. Collecting or producing new data was considered cost-prohibitive or impractical because of limited resources and reporting deadlines.
- **Access.** Data existed and could be located, but could not be acquired in a timely manner (with regard to a specific need). No stewards or point of contacts were available, or funding limitations prevented programs from responding to major data requests from external users.
- **Consistency.** Data were distributed among multiple sources, such as various agencies, districts within an agency, or cooperators, and were inconsistent across sources. Even when data were well documented, their utility was severely limited because of inconsistencies in many characteristics, such as data definitions, standards, quality, extent of documentation, and maintenance.
- **Compilation.** Data may have been accessible, documented, and even consistent across sources, but substantial resources were needed to compile the information to the necessary scale.
- **Maintenance.** Data had not been managed or stewarded over time and required updating or migrating to current standards. Resources were committed to data collection, but no commitment was made to the maintenance of the information.[2]
- **Documentation.** Metadata (information about the data) were missing or incomplete. Even when metadata existed, they were so incomplete or inadequate that evaluating the qualities and utility of the data was unachievable.[3]

Impacts of barriers

The most common barriers to integrating existing data into the effectiveness-monitoring program were consistency, compilation, and maintenance. Often, data were available to address monitoring questions, but other barriers—existence, access and documentation—were encountered in attempts to collate this information into regional datasets.

The lack of consistency among similar kinds of data from various agencies and programs was a primary barrier. Examples included differences in how intermittent streams were mapped and how data on roads and other infrastructures were collected. Another example was the difference in approaches taken to vegetation modeling and mapping across administrative boundaries.

Compilation was another barrier of major importance. It was difficult to develop a regional data layer of riparian corridors and to compile spatial data on ground-disturbing activities across the area managed under the Northwest Forest Plan. Agencies and programs may have tracked projects such as timber sales, mining activities, or restoration projects, but without common standards for data attributes or spatial referencing, compiling the information to the scale necessary for analysis was impossible in many cases.

The lack of maintenance or upkeep of regional datasets was also a significant barrier. Obtaining a regional-scale land use allocation or management zone data layer required substantial effort. Original layers from when the Northwest Forest Plan was implemented—in 1994—had not been updated to reflect changes over the years for attributes such as boundary adjustments or land use zoning. In several cases, the existence of required data was anticipated, but found to be non-existent or incomplete for the area managed under the Northwest Forest Plan. Examples included a lack of digital orthographic photo-quad coverage and a lack of data for determining the cost associated with planning requirements on the whole.

Several issues emerged as secondary or contributing barriers; that is, a primary barrier was encountered, and then further compounded by other issues. Incomplete data were often significant contributing barriers to many information needs, including the identification of riparian corridors and streams. The inability to access data was a significant contributing barrier as well, including basic data on the location of ground-disturbing activities and recreational uses. Missing and inadequate documentation, or metadata, was a very significant contributing barrier to integrating numerous data sources for several needs.

Bridging the barriers

The barriers to integrating existing data into long-term natural resources monitoring and management are more complicated when multiple agencies or programs are involved. In most cases, the solutions are not simple—but neither are they insurmountable. Generally, land-management agencies are at varying stages of maturity with their respective information-management strategies and architectures, and, with few exceptions, interagency coordination on information management is limited—in the past, even avoided. The tendency of agencies, even within a single U.S. government department, to apply different technologies, software, hardware, and intranets (with firewalls), and have differing information-management organizations, produces information environments and "cultures" that present barriers not only to information sharing, but also to basic communication. Cooperating agencies and programs need to provide people with the appropriate authority to overcome information-management issues and barriers to integration. Support staffs with an understanding of natural resources business needs, information technology, agency-specific information environments, and data stewardship, collection, and production are required. Key elements of a proactive strategy to facilitate interagency cooperation on meeting the information needs of broad-scale, long-term monitoring programs include:

- **Adoption of an enterprise approach to data management.** Encourage collaborative actions among agencies and programs collecting and managing essential data. Define the enterprise to include all programs or efforts potentially contributing essential information. Engage these programs in collaborative analysis of requirements so that partner and client needs can be identified and taken into account as data are collected and shared. Support information technologies that are not tied to one agency's or program's information architecture. *Key to bridging all barriers described above.*
- **Executive/management oversight.** Provide directors or other managers with the authority to approve information needs and projects, commit resources, and require accountability. *Key to bridging all barriers described above.*
- **Interagency/interprogram standardization.** Define and document required information standards, metadata, and stewardship needs. Include defining enterprise software and hardware requirements for interagency data structures and information processes. Ensure that the group has knowledge of existing agency information environments, information technology regulations, and cultures. *Key to bridging barriers related to data consistency, maintenance, and documentation.*
- **Interagency/interprogram stewardship.** Support staff positions with knowledge of programs (e.g., monitoring, planning, compliance) and their business needs; those positions require skills to articulate information content, standards, and maintenance requirements, and the ability to work with production staff in developing work plans and budgets. *Key to bridging barriers related to data, compilation, maintenance, and documentation.*

Implementing solutions

By design, land-management agencies are a combination of "top-down" and "bottom-up" organizations relative to decision-making about natural resources. Guidance on process is provided at the departmental and agency levels, but strategies and actions are often delegated to, and developed and implemented at, the local level. Since the establishment of most federal land-management agencies, natural resources data-collection protocols and information-management practices have been typically addressed at the level of the local administrative unit—national forest, district, or national park—or at program levels. The result has been the long-term development of deeply ingrained cultures of distributed decision-making authority and local ownership, which has contributed to the barriers to integrating natural resources science and management. Clearly, applying enterprise concepts and solutions within the existing information-management architectures and cultures of federal land-management agencies is a challenge and will take time.

As was pointed out in the introduction, however, federal land-management agencies are making headway, due to demand and support at the field and departmental levels. The U.S. Forest Service, for example, is in the midst of a long-term effort to implement the Natural Resources Information System (NRIS). The NRIS combines standard corporate databases and computer applications to support field-level users. The data models are managed nationally, but the applications are installed and managed in a distributed manner, typically at the regional and forest levels. The transition from local to enterprise solutions has been as much a cultural as a technological change for the Forest Service, and investments have been large—approximately $10 million per year during the first few years of NRIS development.

Within the National Park Service, another significant effort is underway to define business-driven requirements for managing natural resources information: Protecting Resources through Informed Decisions and Education, or PRIDE. PRIDE is following the Department of Interior's Methodology for Business Transformation (MBT) process, which is expected to generate a servicewide blueprint for enterprise information architecture that will include natural resources inventory, monitoring, and research data. The Park Service has also implemented programs that are generating changes in the agency's culture with regard to natural resources science and monitoring information. The Inventory and Monitoring program groups over 270 parks into 32 networks. In the past, parks were relatively independent entities, and often had to compete for the same financial resources. With the network approach, network parks share resources for monitoring natural resources conditions and trends. The program has a policy of committing one-third of its resources to data management and reporting. Numerous other federal agencies are also implementing solutions to natural resources information-management barriers, including the Bureau of Land Management and Environmental Protection Agency.

Replacing information-management barriers with bridges is critical to integrating natural resources science, planning, and management. The success of many natural resources planning and monitoring efforts, such as the Interagency Northwest Forest Plan and National Park Service Inventory and Monitoring program, depends on enterprise-type solutions that promote reasonable levels of standardization and information stewardship to ensure that data are usable. The solutions must address issues related to data access, consistency, compilation, maintenance, and documentation across agencies, programs, and partners that expect to share information for the purpose of managing the vast natural treasures on public lands.

Endnotes

1. These agencies have all adopted the same definition for "enterprise architecture": A strategic information asset base that defines the business, the information necessary to operate the business, the technologies necessary to support the business operations, and the transitional processes necessary for implementing new technologies in response to changing business needs. It is a representation, or blueprint.
2. Because of the substantial costs of maintaining data, such as inventories and other sources of land-management information often used in planning, data sometimes suffer

from neglect. In the short term, recollecting data according to the planning cycle can seem more cost-effective than using existing data. However, this strategy ignores long-term needs for maximum use of existing data to maintain historical baselines.
3. Creating or recreating the documentation years after the data had been produced is often impossible because of attrition in institutional knowledge.

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The Challenge of Communicating Monitoring Results to Effect Change

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The Natural Resource Challenge legacy

SINCE ITS INCEPTION, the National Park Service (NPS) has been charged with preserving the natural and cultural heritage of the United States for future generations. It is only recently, however, that the NPS has fully embraced the need to understand and describe the ecology of parks. The infusion of an ecological perspective into the natural resource management of the national parks is what separates today's park management from much of that which preceded it (Sellars 1997). The guiding principles set forth by the agency's National Leadership Council as part of the Natural Resource Challenge (NPS 1999; hereafter "the Challenge") shepherded these perspectives into present NPS culture and practice. Ultimately, the insights, common goals, and collaborations we describe in this essay have all been made possible by the vision and funding of the Challenge, the most recent high-water mark for embracing science within the NPS.

In this paper, we discuss a special collaboration enabled by the Challenge, in which an inventory and monitoring (I&M) network (National Capital Region Network; NCRN), a research learning center (Urban Ecology Research Learning Alliance; UERLA), and a cooperative ecosystem studies unit (Chesapeake Watershed CESU) partner (University of Maryland Center for Environmental Science; UMCES) coalesced around a common goal: to collect, analyze, and interpret data in national parks, and to promote learning and understanding. We describe a set of tools and principles for integrating and communicating science that we believe have broad utility in the practice of natural resource stewardship. Furthermore, we stress the iterative and collaborative nature of communicating results and how the process of communication leads to shared investment and stimulates new areas of scientific inquiry.

Recognizing the need to communicate scientific results

Although the NPS I&M networks were not explicitly charged with developing communication products, sharing scientific results is a logical and necessary outgrowth of natural resource monitoring because the results need to be used for making management decisions. Simply collecting data—or even increasing our ecological understanding—will not necessarily help us reach our ultimate goal of informing management practices. As the Challenge aptly states, "Once this information is in our hands, we must share it widely, so that child and adult, amateur and professional can benefit from the knowledge uncovered in these places" (NPS 1999).

A shared goal of all the Challenge programs (e.g., inventory and monitoring programs, research learning centers, exotic plant management teams, and cooperative ecosystem studies units) is to integrate science and management. Achievement of these goals will greatly depend on the internal capacity of individual parks to gain and share knowledge. Thus, incorporating scientific information into management decisions requires not only the transfer of information in the form of organized, interpreted data, but also a contextual framework that embraces the experiences and values of managers and the public. Now more than ever, we NPS heirs to the Challenge must show that we are acquiring the information we need, and that our ability to protect resources has improved. We believe that a sound communication strategy, using interesting, synthetic, and contextualized products, will not only serve managers' needs, but also sustain public trust and promote public scientific literacy.

The three principles of science communication

The need to communicate monitoring results led the NCRN and UERLA, in tandem, to collaborate with the Integration and Application Network (IAN) based at the UMCES. The IAN is an interdisciplinary team of scientists working to transform raw data into synthesized information and to communicate findings in effective ways to promote knowledge-building (Thomas et al. 2006). Each step of the process involves key stakeholders and uses three basic principles of science communication: visualization, contextualization, and synthesis (Thomas et al. 2006). Below, we describe how these principles can be applied to help provide a comprehensive understanding of monitoring results. In this paper, we illustrate the application of these principles with reference to our shared experience in the National Capital Region.

Visualization. The purpose of visualization is to answer the questions, "who?", "what?", "where?", and "when?" so people can understand *"why?"* Visualization elements include conceptual diagrams, maps, photos, extended legends, charts, and graphs. Each type of visualization plays a different role in describing ecological phenomena; collectively, they create a comprehensive explanation that no single chart, map, or photo can provide. Thus, the process of communicating science becomes less audience-specific, because all readers are likely to be able to view results in a format they prefer.

Conceptual diagrams provide a particularly effective means of combining diverse types of information into an integrative science understanding. They are "thought drawings" underpinned by actual data. A conceptual diagram is similar in many ways to a traditional conceptual model (e.g., box-and-arrow model) but has a few fundamental differences (Figure 1). Like conceptual models, these diagrams show important components of ecological systems. They can show processes, pathways, flows, and indicators, as well as interactions between them. Also, conceptual diagrams can include several levels of complexity (similar to sub-models) that show particular phenomena in greater detail. A primary difference between conceptual models and diagrams is the use of visual elements. Whereas models generally employ standard geometric shapes to depict drivers, stressors, regulators, and other elements, conceptual diagrams use more intuitive symbols to represent data and key results, with a suite of

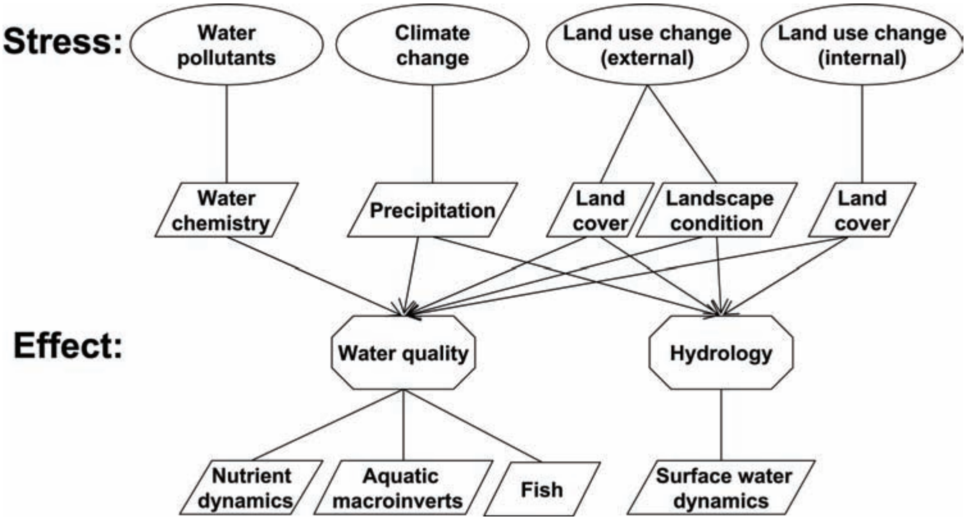


Figure 1. A comparison between a conceptual model (above) and a conceptual diagram (facing page) for water quality. Both graphics are supported by data and show linkages among key indicators, processes, and threats. The judicious use of symbols and an extended legend in the diagram improve understanding and aid visualization of the primary issues.

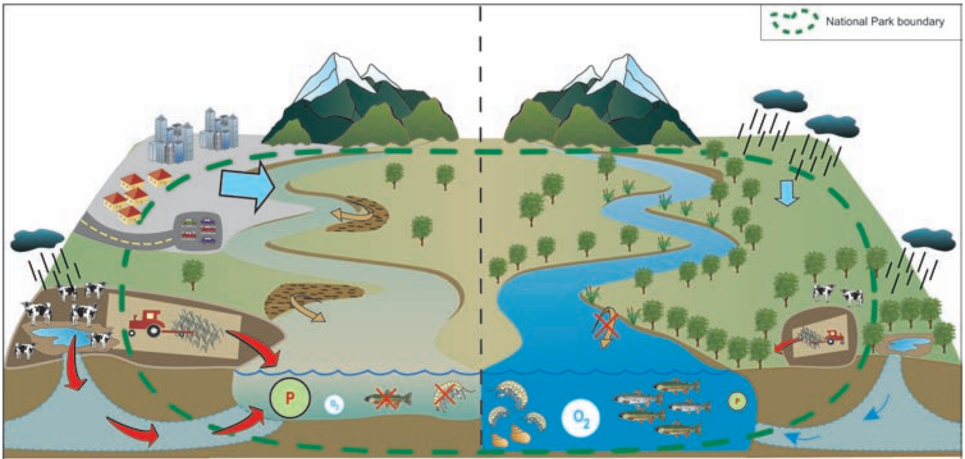
symbols that either provide a graphical (i.e., lifelike) representation or demonstrate an abstract process (e.g., arrows denoting flows).

Symbols are unambiguous and can be easily shared, thereby promoting a consistent message among different programs or perspectives. Symbols can also be used independently of language and explanations; over time, a comprehensive collection of symbols can essentially represent an unspoken language (see http://ian.umces.edu/symbols/). In addition to design, the placement, size, and number of symbols used also convey meaning. Larger size and greater numbers can indicate more significance, while placement provides geographic context (see "Contextualization," below). Both conceptual models and conceptual diagrams are useful tools for defining ecological systems, but the intuitive, universal appeal of symbols improves understanding and attracts a broader audience to carefully crafted conceptual diagrams.

Contextualization. Providing appropriate context is essential for communicating complex ecological monitoring data that have many interrelationships in space and time. Context adds to visualization by personalizing an issue; different types of context can offer a unique understanding depending on the audience's perspective. We discuss three types of context: thematic, geographic, and indicator-based.

Conceptual diagrams provide necessary thematic context. They are stylized and often transferable beyond the immediate study site. For example, a conceptual diagram of an urban environment has appeal and applicability not only to the National Capital Region but also to other urban parks throughout the country. We have constructed ecological stories, or "vignettes," that are pertinent to NCRN parks and also have broad appeal. A thematic overview of stressors on water quality associated with

HABITAT: WATER QUALITY



IMPAIRED STATE	VITAL SIGNS	DESIRED STATE
HIGHLY VARIABLE Impervious surfaces alter the timing and magnitude of stream flows	surface water dynamics	STABLE Intact watersheds and few point sources buffer streams against flood events
UNSUITABLE FOR BIOTA Upstream and surrounding land use can impair core water parameters	water chemistry	SUSTAINS BIOTA Clean water allows for sustainable populations of biota
EUTROPHIC High inputs of nutrients result in eutrophication	nutrient dynamics	OLIGOTROPHIC Intact forests and wetlands filter out nutrients
DEPAUPERATE AND DISEASED Poor water quality reduces diversity and abundance of macroinvertebrates	aquatic macroinvertebrates	DIVERSE AND ABUNDANT An abundance of macroinvertebrates indicate good water quality
LOW Shallow and scoured stream beds and eroded bank sides reduce habitat quality	physical habitat index	HIGH Deep water, intact stream substrate, and stable banks provide good habitat
DEPAUPERATE Poor water quality reduces diversity and abundance of fish	fish	DIVERSE AND ABUNDANT Diverse and abundant fish populations are found in high water quality streams

an urban setting provides a useful context for interpreting the monitoring data being collected in the NCRN (Figure 2).

Maps and photos with extended legends provide geographic context. Good maps and appropriate photographs have tremendous value because they explicitly address spatial scale. Using carefully placed, synthesized data on a map is one of the best ways to show relevance and integration (Figure 3). Maps allow us to visually integrate the human and natural realms. Through maps, we can also speak to people's sense of place, facilitating connections and allowing comparisons. Photographs provide an additional sense of place that maps and graphs cannot capture. Photographs also enhance unique perspectives that the casual visitor would not be able to experience otherwise (e.g., aerial, underwater, macro-scale, or historical; Figure 4).

Another form of context can be based on environmental indicators themselves. Using an indicator-based context helps to

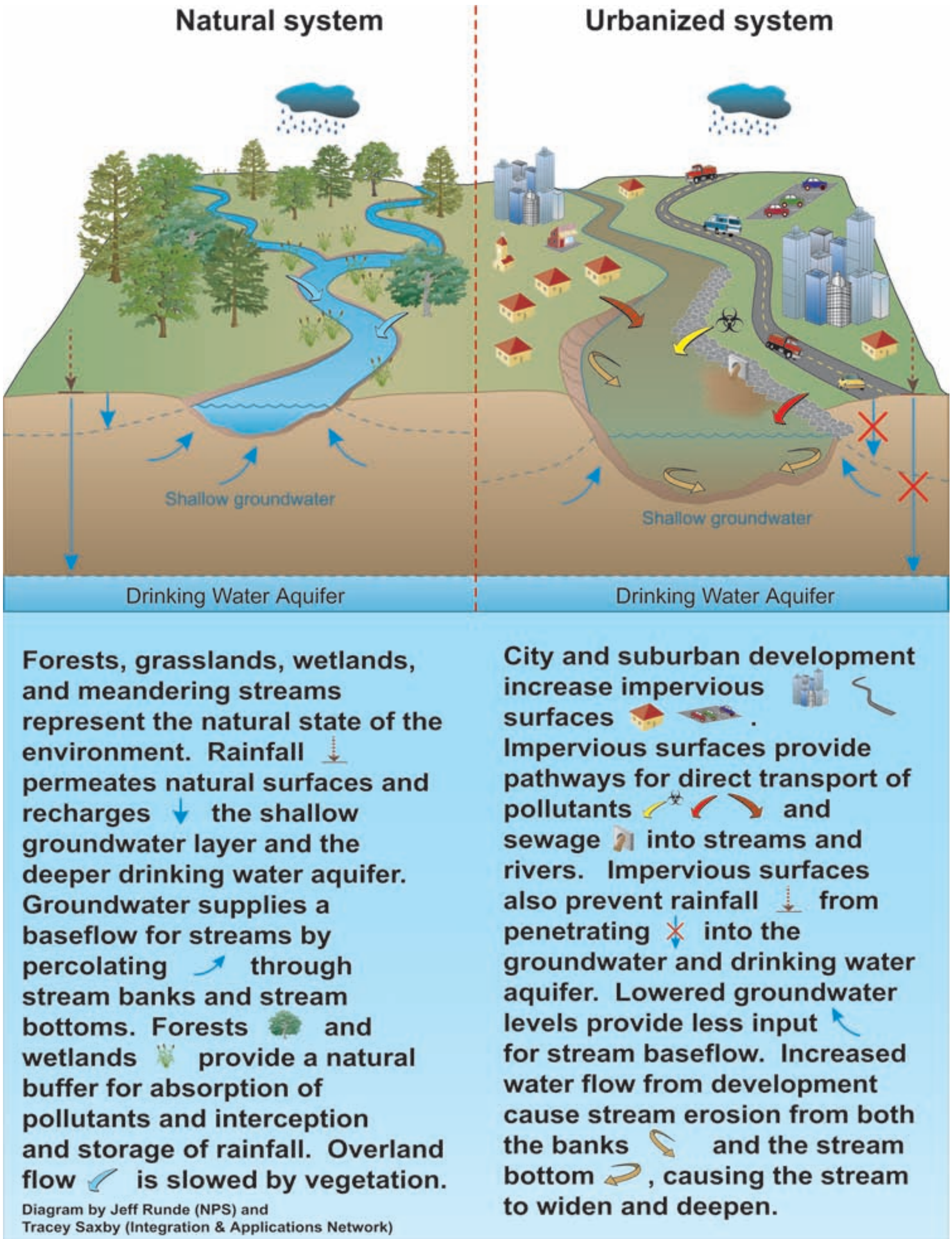


Figure 2. A theme-based conceptual diagram showing urban threats to water quality. While especially relevant to the National Capital Region, processes and threats can easily be generalized to other regions or parks.

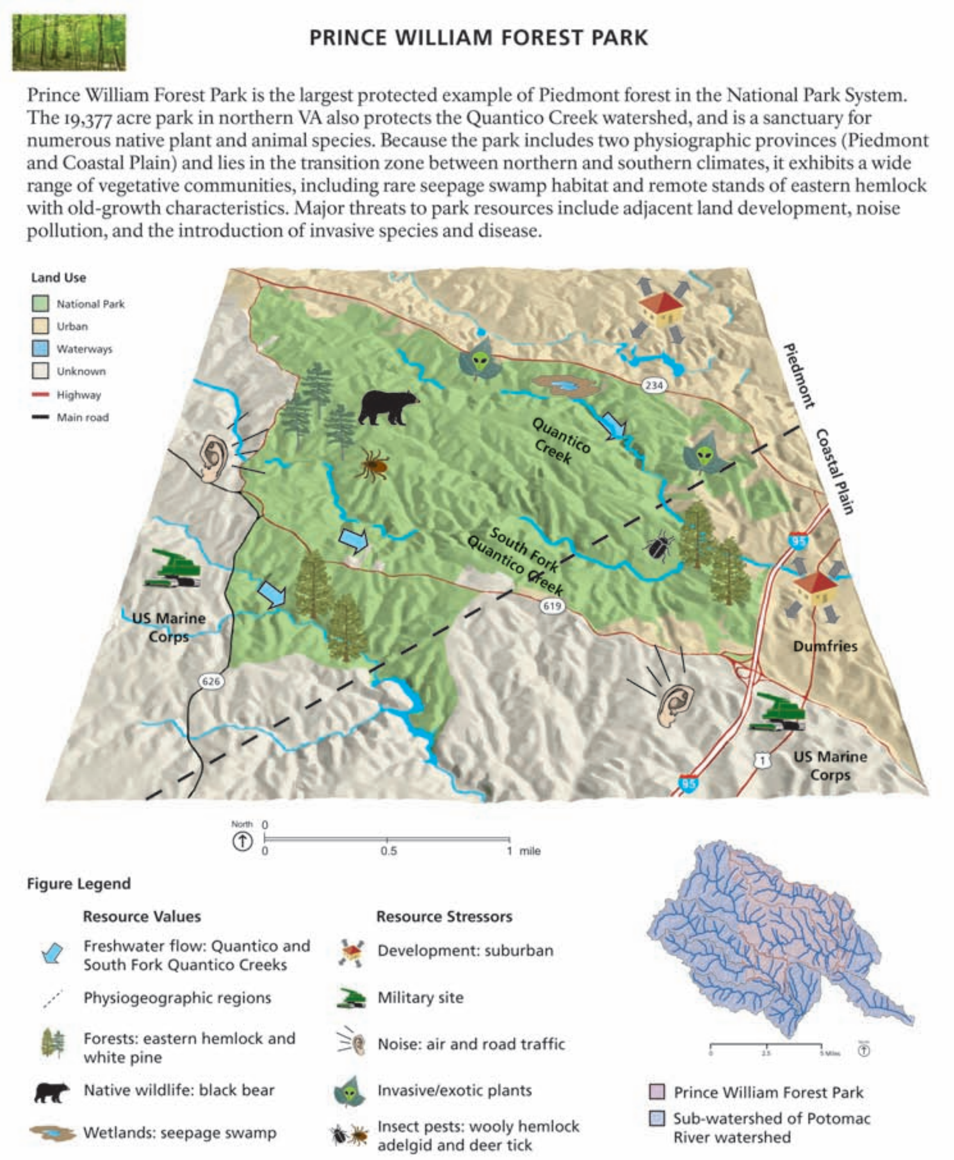


Figure 3. Spatially explicit map for Prince William Forest Park. Symbols are used to locate and show relative importance of park resources and threats. Broader geographic context is given by showing the broader surrounding watershed (Potomac) and key physiographic zones (Piedmont and Coastal Plain).

Figure 4. Aerial photos that portray geographic context show that adjacent development can impact national parks within urban areas. Photo courtesy of Tom Paradis.

address the continual challenge of defining what is being monitored (e.g., a vital sign) versus what is being measured (e.g., a metric). For example, if the indicator of interest is water quality, then many measures may be considered (e.g., dissolved oxygen, contaminant levels, nutrients, or ionic concentrations). Thus, a broader suite of variables offers context to help readers to better understand each indicator and how it relates to other vital signs and a much larger ecological framework (Figure 5).

Synthesis. Decision-makers don't need all the data related to a subject; they need relevant data. This is why providing synthesis is particularly important for achieving science-informed management decisions. More than an academic exercise in data analysis, proper synthesis is a "process of relating." Several rules of thumb shape our choices for how to synthesize data:

- **Naïve audiences are not stupid audiences.** Credible science and technical detail underpin the collection and analysis of monitoring data, and such a foundation is crucial to understanding results. Effective communication attempts to maintain high standards of quality without sacrificing clarity.
- **Technical detail is not necessarily clutter.** Details add value when appropriately presented. On the other hand, simply adding more data and results does not equate to adding more value, insight, or significance.
- **A simple conclusion is not a simplified one.** Audiences will appreciate the distillation of results into meaningful

conclusions, but this does not require "dumbing down" the message.

- **Jargon does not bolster scientific credibility.** Rather, the effective presentation of results relies on common sense, logic, and reason.

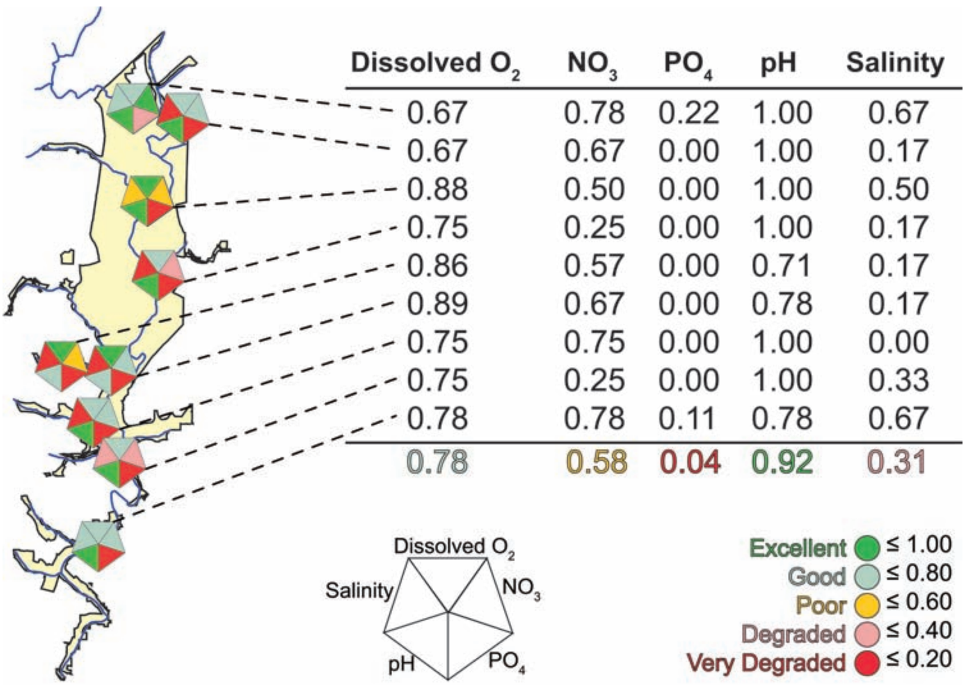
Visual elements (e.g., charts, graphs, symbols, and extended legends) effectively address these guidelines and are essential tools for relating results and meaning.

The internet offers a powerful opportunity to blend verbal, quantitative, and qualitative elements to achieve visual and cognitive synthesis of data. Information pathways can offer different types of context for synthesis: *conceptual* (theme-based), *geographic* (place-based), and/or *indicator* (attribute-based). This approach to synthetic data offers the advantage of providing access to information in different ways, depending on the interests of the end user (Figure 6).

Theme-based synthesis uses conceptual diagrams to provide linkages between the data and universal or generalized ecological concepts (e.g., biogeochemical cycles, climate variability, land use dynamics). Theme-based diagrams indicate commonalities among indicators or processes, describe broad-scale, complex ecological relationships, and are more likely to draw upon data for a suite of indicators (e.g., air quality) than any particular attribute.

Place-based synthesis uses spatially nested, georeferenced diagrams to define

Figure 5. An ecological assessment for water quality data at Rock Creek Park. Data shown represent the percentage of time when measurements fell within acceptable state regulatory standards. Individual measures of water quality are shown together in a spatially explicit form. This format conveys measure-specific information while also showing how measures relate to one another.



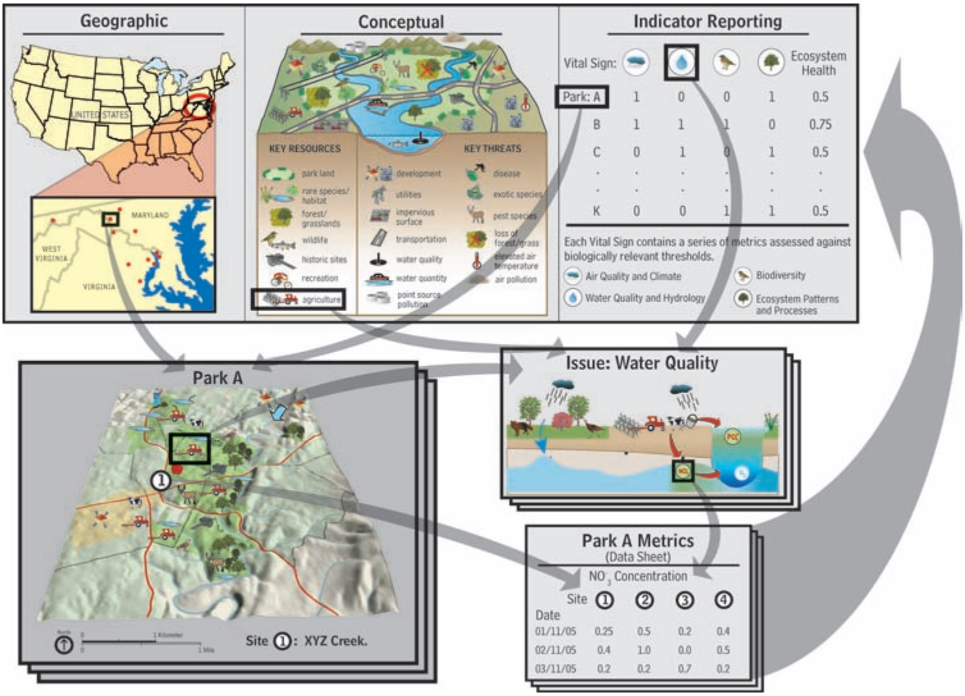


Figure 6. Overall framework for obtaining synthesized data using multiple navigation pathways. Park conceptual diagrams are linked by a geographic map and appropriate monitoring indicators. Ecological themes ("vignettes") become sub-models to illustrate park-based issues within a regional context. Data support the entire framework and can be queried and summarized according to the navigational path chosen (after Dennison et al., in press).

the spatial extent of the data being accessed. A major benefit of a place-based navigation pathway is that it allows users (e.g., park managers) to easily determine where data are being collected within a park, which provides context for related monitoring or research efforts.

Indicator-based synthesis selects data according to a particular attribute of interest. Data may be accessed at hierarchical levels depending on the needs of the user. A person searching for information on water quality, for example, might find data on a suite of different indicators. Alternatively, a person could also access data for a particular indicator of interest (e.g., dissolved oxygen). Indicator data also can be cross-linked to maps and conceptual diagrams using symbols to provide attribute information for specific locations (place-based) or conceptual ideas (theme-based).

Why the IAN-NPS model works

We have purposefully adopted a series of principles that will help us align the capabilities, interests, and needs of researchers, managers, and citizens. The result is a communication strategy that creates, verifies, and applies new knowledge. Our goal is not only to transfer information in the form of organized, interpreted data, but also—and more importantly—to assist with thinking about that information and to build shared understanding. The distinction we make between transferring information and generating knowledge is important. Generating knowledge requires a conceptual framework that both incorporates existing data and captures the experiences, values, and context of researchers, managers, and the public alike. We believe that it is the process of shared knowledge-building, rather than the simple transfer of information, that improves the capacity of managers to make informed decisions and therefore invoke more effective actions.

Our process for communicating science is a team effort, takes time, and produces tangible results. Scoping workshops with park resource managers and interpretive staff have been used to create and refine conceptual diagrams (Lookingbill et al., in press). The NCRN has played a large role in contributing synthesized data, the UERLA has worked closely with park staff to construct and understand the models, and UMCES, our academic partner, has been instrumental in evaluating and improving our models. Conceptual diagrams have been invaluable for establishing a common understanding of resource values and priorities. The very process of defining appropriate symbols for indicators, deciding where they should be placed and how large they should be, and seeking agreement among those outside the park, though time-consuming, has created a shared vision for monitoring priorities in the region. While driven to produce particular products (e.g., conceptual diagrams, newsletters, booklets, posters, a website), we have found that the process of creating these products has generated and reinforced an effective collaboration. This gives rise to our recommendation that each stage of a collaborative program should have a product focus to maintain and enhance the collaborative process.

No single communication tool can provide everything needed to promote informed environmental stewardship. Just as each of our partners has brought an integral component to our communication strategy, each product addresses slightly different needs based on the individual perspectives of the greater public. Newsletters, booklets, posters, conceptual diagrams, charts, figures, and websites are all valuable tools. By incorporating key principles and guidelines into each of these products, a consistent, broad-reaching message can be communicated, providing proof positive that the NPS is living up to "the Challenge" of preserving our shared natural resource legacy.

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Linking Monitoring to Management and Planning: Assessment Points as a Generalized Approach

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Introduction

One of the major reasons for implementing an environmental monitoring program is to provide early warning of abnormal conditions, impending concerns, or potential shifts in resource values relative to management goals. Given the complexities of the ecosystems being monitored by land-management agencies and the myriad indicators that are used to assess these ecosystems, even the most diligent resource manager could fail to recognize the signals of impending change in the absence of an explicit process for systematically assessing sometimes subtle and cumulative evidence. In this paper, we offer the concept of assessment points as a tool for improving our ability to use monitoring data to inform the management of parks and protected areas.

Put simply, "assessment points" represent preselected points along a continuum of resource-indicator values where scientists and managers have together agreed that they want to stop and assess the status or trend of a resource relative to program goals, natural variation, or potential concerns. These points provide an opportunity to synthesize and consider a wide variety of information about the desirability, acceptability and risks imposed by the status and trend of the resource(s) in question at that point and to further consider potential management options. As such, assessment points provide a means of detecting conditions that may warrant management action with sufficient lead time to enable managers to identify and implement options that may halt or reverse an undesirable trajectory before significant damage occurs.

The idea of assessment points is not new, nor original to this paper. Rather, in this effort we have attempted to: (1) build upon good ideas that have come before us, (2) overcome perceived challenges to the widespread use of existing concepts, and (3) facilitate application of these concepts into management planning and decision-making processes for North American parks and protected areas.

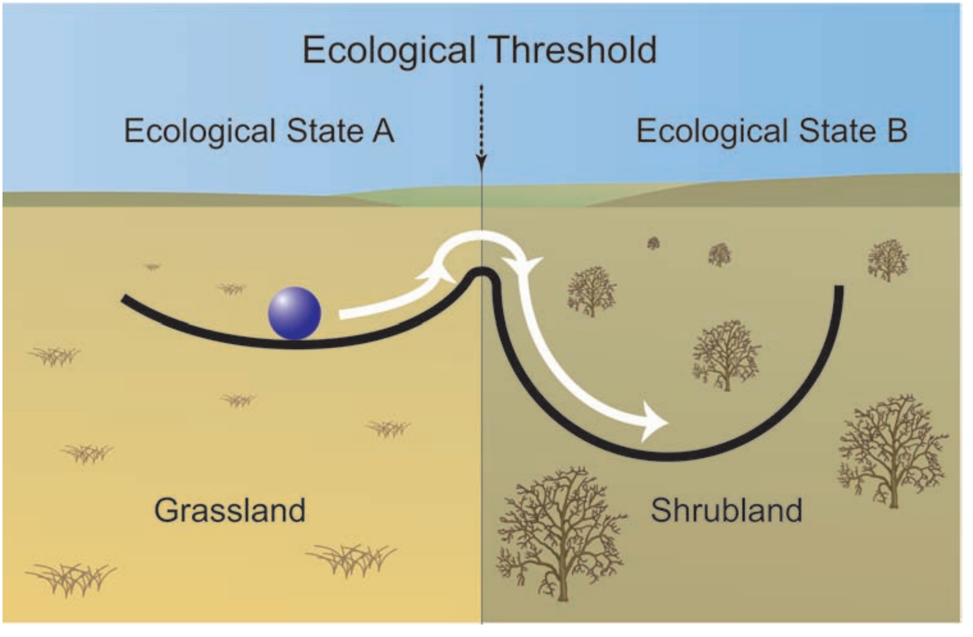
In what follows, we describe some of the existing concepts upon which the idea of assessment points is based and identify challenges to their incorporation into a management context. We explain how assessment points can be viewed as a unifying tool that enables several of these evaluative approaches to be incorporated into a single, generalized conceptual framework for using monitoring data to inform management. We outline different types and uses of assessment points and provide an example of how they could be applied in a management and planning context. Finally, we offer some advice on how to get started using assessment points.

Other concepts that identify points or zones of interest

Ecological thresholds. Among the many definitions of the term "ecological thresholds," a common thread is that they represent a point or zone in which abrupt change occurs in some ecosystem condition (e.g., a state, pattern, or process; Figure 1) (Radford and Bennett 2004; Groffman et al. 2006). Ecological thresholds are important to managers because there are consequences to crossing them. Some changes are practically irreversible, while many others can be reversed only at great expense (Groffman et al. 2006).

Despite widespread agreement among scientists that ecological thresholds are real and can be extremely important, they have not been widely used or accepted by managers. One of the biggest challenges to using ecological thresholds in a management context is the uncertainty or unpredictability involved. Because threshold responses are often complex and influenced by multiple factors (Lindenmayer and Luck 2005; Groffman et al. 2006), we can rarely predict an impending threshold-type change with any confidence. For example, of the nearly 100 examples of threshold-type changes documented in a single database (Resilience Alliance 2007), most were described only after they occurred. In addition, the act

Figure 1. Ecological thresholds are often illustrated by a ball-and-valley diagram to represent the tendency to stay or return to a given ecological state or condition or the energy required to change to an alternative condition.



of trying to determine quantitative points representing the threshold between "desirable" and "undesirable "is problematic given its subjectivity and frequent differences of opinion by stakeholders. Not surprisingly, natural resource managers have been reluctant to base decisions on poorly understood threshold values or responses.

Another obstacle to more widespread use of ecological thresholds includes the ease with which gradual change, occurring before a threshold is reached, can be overlooked (Lindenmayer and Luck 2005). Issues of spatial and temporal scale, such as when resources are influenced by factors that extend beyond park boundaries (Jones et al. 1996; Groffman et al. 2006), or when park resources may be more a reflection of past land use changes than current park habitat condition (GAO 1994; Woodroffe and Ginsberg 1998), are also challenging.

Critical loads. The idea of critical loads was developed in Europe for assessing atmospheric deposition (Nilsson and Grennfelt 1988). In North America, critical loads are similarly used to protect federal land resources from negative impacts of atmospheric deposition (Porter et al. 2005). Critical loads represent the amount of exposure to one or more pollutants an environment can tolerate before suffering harmful effects. Although similar to the idea of ecological thresholds, the concept of critical loads is used in a relatively narrow context, where predictability of harmful effects is more likely. As such, it is often used as a policy or regulatory standard (see below) where the harmful effects of concern are explicitly specified.

Regulatory or policy limits and standards. A wide variety of limits and standards are used in a policy or regulatory capacity. These are usually based on health effects (e.g., Environmental Protection Agency [EPA] primary standards) or environmental effects (e.g., EPA secondary standards), and generally represent the acceptable limits of a given condition. State and federal standards of air and water quality are well-known examples. The National Park Service (NPS) uses standards in conjunction with indicators as an approach to facilitating decisions regarding the management of public use (user capacity) (NPS 2005a; Figure 2). User capacity indicators represent measurable parameters used to track changes relative to desired resource conditions and visitor experiences that are affected by public use—similar to the way in which the NPS Inventory and Monitoring Program (I&M) monitors "vital signs" in order to track changes to natural resource conditions (Davis et al. 2003). In contrast, user capacity standards represent the minimum acceptable condition for each indicator, and are used as a "management threshold" (see below) that requires action.

Management threshold. A management threshold represents a point or zone that triggers management action within a given context. The key distinction between ecological and management thresholds is whether it is an ecosystem that undergoes change (ecological thresholds), or the management of that ecosystem (management thresholds) that undergoes change when a threshold is crossed. However, management thresholds are intended to facilitate *a priori* consideration of undesirable ecosystem changes (e.g., ecological thresholds) and enable more proactive management responses.

Management thresholds also have not achieved widespread acceptance as a management tool among protected area managers. One likely reason is that park and

Figure 2. User capacity represents the types and levels of visitor and other public use that can be accommodated while sustaining desired resource conditions and visitor experiences. Photo credit: National Park Service/Jim Peaco.

reserve management decisions are not based solely on ecological science; managers need to integrate ecological, social, economic, and political values into management decisions (see also Lewis, this issue). Management thresholds are often perceived—rightly or wrongly—as being too inflexible to accommodate these alternative values, and managers can be understandably reluctant to adopt management actions without considering the full suite of values at the time a decision is made.

Desired condition/desired future condition. The concept of "desired future condition" was pioneered by the U.S. Forest Service (USFS) as part of its strategic planning process in the 1970s and 1980s (Leslie et al. 1996). Since that time, the idea has shifted and evolved within a variety of organizations and contexts, and has been used somewhat differently by different organizations (see also Bennetts and Bingham, this issue). The USFS typically used desired future conditions to define the desired state for each management unit within a national forest, often with respect to a potential vegetation condition (USFS 1993). For instance, a desired future condition could emphasize forage or timber production, leading to the desired state of a climax vegetation community. While today's USFS terminology refers simply to "desired conditions" (36 CFR 219.7), the concept remains in use. Within the NPS general management planning process, a "desired condition" is a park's natural and cultural resource conditions and corresponding visitor experiences that the NPS aspires to achieve and maintain over time (NPS 2006a).

Range of natural variation. "Range of natural variation" and associated terms (e.g., "natural variation," "historic variability") represent an idea that broadly surfaced in the 1960s as a means of guiding natural resource management (Landres et al. 1999). These ideas were largely based on a recognition that past variation in ecosystem conditions and processes could provide a context for guiding current natural resource management decisions, and that disturbances in space and time that resulted in variation were a necessary component of virtually all ecosystems. However, three common criticisms of this approach are that: (1) most ecosystems are no longer sufficiently pristine to enable such evaluations, (2) points in space and time represent a snapshot of specific conditions that are constantly changing and may not be a relevant basis for management, and (3) establishing management goals to limit the range of variation results in maintenance of a static condition for ecosystems that otherwise can be highly dynamic (Landres et al. 1999).

Thresholds of potential concern. Thresholds of potential concern (TPCs) were developed at South Africa's Kruger National Park (Biggs and Rogers 2003; Figure 3), where they were defined as "a set of operational goals that together define the spatiotemporal heterogeneity conditions for which the Kruger ecosystem is managed. TPCs are essentially upper and lower limits along a continuum of change in selected environmental indicators. The suite of

Figure 3. Thresholds of potential concern were developed at Kruger National Park to represent the limits of acceptable conditions, and were used for such purposes as managing elephant populations. Photo by Roy Johannesson courtesy of South African Tourism.

TPCs together represents the envelope within which ecosystem changes are considered desirable" (KNP 2007).

The TPC approach attempts to articulate predetermined responses (e.g., management triggers), as expressed by Foxcroft (2004): "An important aspect of the TPC is that they are preagreed goals, and thus, consensus has already been reached on possible sets of future actions, once the TPC is reached. This therefore implies that management is prevented from stalling or procrastinating at such point." Although we agree that having predetermined management responses is a desirable target for the future, we also believe that managers need an approach that will allow them sufficient flexibility to simultaneously consider a full suite of alternative values (e.g., ecological and social) in a given context. Thus, except where law or policy has determined, *a priori,* that some resources be given priority, having predetermined solutions may not be realistic in many situations. Having explicit assessment points along a continuum of resource conditions can provide a means of guarding against stalling from a lack of information while simultaneously allowing the flexibility needed to incorporate alternative values.

TPCs also extend the idea of ecological thresholds to include the limits of acceptable conditions; however, they are still based on a real or hypothesized ecological envelope of those limits. We extend the application of TPCs slightly to further include legal limits, subjective criteria, and other points where we feel an assessment might be warranted. Our treatment of assessment points is strongly based on Kruger National Park's development of TPCs; we have simply adapted the ideas and the terminology of TPCs to better reflect the North American park monitoring context. Readers are strongly encouraged to explore the extensive work on TPCs at Kruger National Park (KNP 2007).

Assessment points as a unifying tool

All of the concepts above define, either objectively or subjectively, a reference state, condition, or process that we wish to maintain or avoid through management actions (Table 1). In contrast, assessment points are a means of evaluating states, conditions, or processes, and linking monitoring to management actions. We do not suggest that assessment points can or should replace these other concepts. Rather, we believe that assessment points can be used as a common framework to complement these other concepts, and bring added value when used in conjunction with them. Concepts such as ecological thresholds and standards can easily be accommodated within the framework of assessment points, and will often form the basis upon which assessment points are assigned.

> ***Assessment points are a means of evaluating states, conditions, or processes, and linking monitoring to management actions.***

Assessment points bring additional information to bear along the trajectory of an indicator or vital sign, such as whether the trajectory is moving toward the ecological threshold or standard, how quickly that value is likely to be reached, and whether or not other indicators or vital signs are consistent with any undesired change (Figure

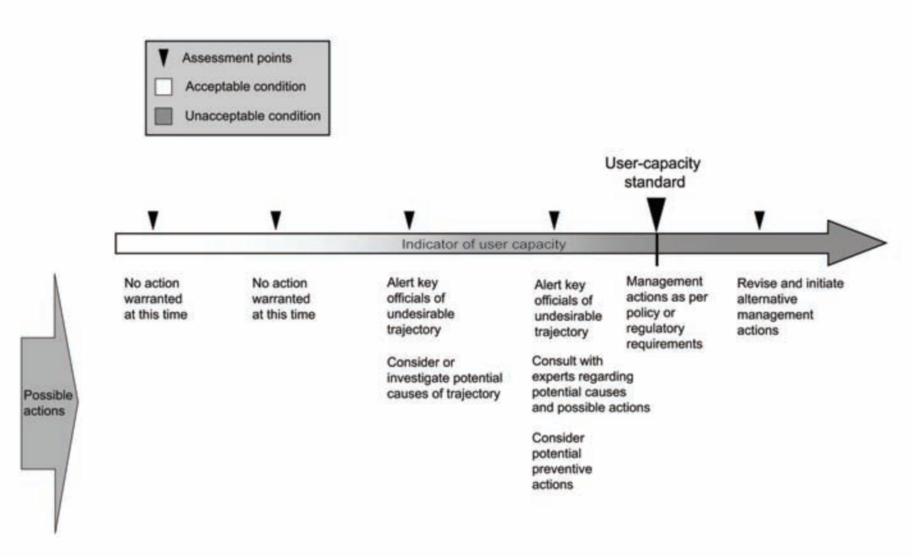
Table 1. Commonly used concepts that describe, either objectively or subjectively, a state, condition, or sometimes a process that management wishes to avoid or to maintain.

Concept	Management aim
Ecological threshold	Avoid
Critical load	Avoid
Policy or regulatory standard	Avoid
Management threshold	Avoid
Desired condition	Maintain
Range of natural variability	Maintain
Thresholds of potential concern	Avoid

4). In short, assessment points can serve as "road signs" (see Carter and Bennetts, this issue) whose purpose is to inform management about the status and trend of an indicator or vital sign, as well as provide additional available information.

In addition, the process by which we propose to use assessment points can be a useful tool for informing management in anticipation of any trajectories of concern. Assessment points provide an opportunity, but not an obligation, for managers to take

Figure 4. Concepts such as regulatory or policy standards, or ecological thresholds, can and should be used as assessment points. Additional points can be used to account for uncertainty, evaluate the trajectory toward a point of particular interest, or to consider alternative management options that might halt or reverse and undesirable trajectory before it reaches the threshold or standard.



action prior to reaching a value where a stronger response may be warranted. Such actions could include informing key collaborators of an impending value of importance (e.g., ecological threshold or standard) or compiling information about potential consequences of alternative responses.

Assessment points as part of an adaptive process

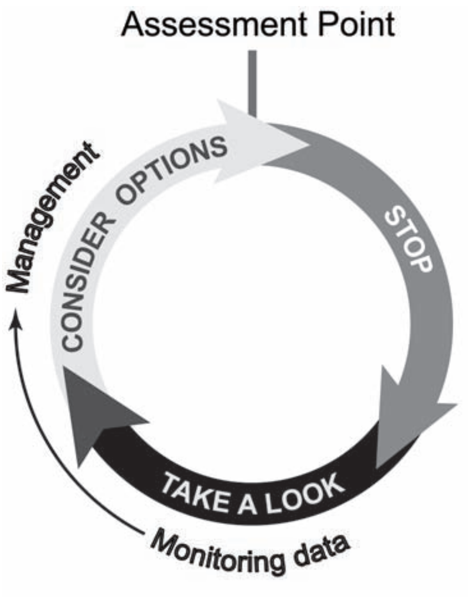
Assessment points are points along the distribution of values (i.e., spectrum of condition) of vital signs or indicators (including stressors and drivers) where managers and scientists agree to stop and take a closer look at existing data to determine the level of risk to a resource. An assessment would typically consider such questions as:

- Are we at risk of crossing a threshold or standard?
- Is the trajectory headed toward a threshold or standard?
- How much time do we anticipate it might take to reach a point of concern?
- What actions might we take that to slow, halt, or reverse the undesirable trajectory?

This "closer look" may or may not lead to a decision to act beyond the assessment itself. The key point is to articulate a process that leads to early detection or anticipation of a potential problem, and to identify and encourage actions that reduce costs and consequences by addressing problems while they are smaller and easier to treat. Below, we outline our general view of a process that is formal, in the sense of being laid out in advance, but also highly flexible and adaptable to the institutions and context in which it is applied (Figure 5).

Stop. The first job of an assessment point is to ensure that there are pre-established circumstances when we stop to engage in an assessment. Having these pre-established circumstances in place is a particularly effective way to decrease the likelihood that subtle changes will evade detection in the course of day-to-day operations. How frequently we assign assessment points will depend on our level of uncertainty about system responses, as well as how conservative we want to be in our detection of changes. The frequency of assessment should be tailored to the needs of a given agency or organization, and it should be adaptable. After one or two assessments, a decision may be made to increase or decrease the frequency or intensity (discussed below) of assessments. At Kruger National Park (Biggs and Rogers

Figure 5. Assessment points can be viewed as part of an adaptive process in which managers and scientists agree to stop and take a closer look at existing data to consider the level of risk to a resource as well as possible actions that might be taken.



2003), managers found that early in their program, their thresholds of potential concern were being reached too frequently, resulting in excessive time and effort. In such cases, the solution is simply to adjust the assessment points until the "right" frequency and intensity of evaluations are achieved.

Take a look. This is the stage at which monitoring data play the strongest role, because it requires checking the status of a suite of appropriate indicators. Status can be evaluated by metrics such as the number of indicators that suggest concern is warranted, or how close the values of indicators are to reaching an undesirable condition.

However, as we have emphasized, adaptability to the particular institutional framework will be a key to success. An assessment need not be an extensive, costly effort if the assessment point was conservative and there is little evidence that indicators are pointing to a problem. In contrast, indications of an imminent, important change would trigger a more intense assessment that could include alerting additional staff of the problem, engaging additional experts, or commissioning a separate study. If management actions resulted from previous assessments, then the management response should be included as part of the current assessment.

Consider what, if any, management options should be exercised. The intention of this step is to consider whether action can, or should, be initiated when the condition of a resource has reached, or is approaching, an undesirable state. The intent is not to dictate an *a priori* decision to initiate a specific management action, except where other mandated standards or thresholds already exist, or when agreement on the appropriate action has previously been made. At this step, the total suite of values could be considered in the context of the strength of the evidence that an undesirable condition has occurred or is forthcoming, and of the seriousness of that condition (e.g., Is it reversible? What other ecosystem components are likely to be affected?).

In addition to direct resource management action, other potential actions include:

- Informing certain individuals of the current condition or trajectory;
- Synthesizing information on management options in advance of a future assessment point;
- Considering or commissioning supplementary research;
- Evaluating the risk and costs of not taking action at this time; and
- Consulting other experts.

Types of assessment points

Assessment points, as we envision them, may be assigned for a variety of reasons (see below) and expressed in a variety of forms. To be meaningful, assessment points must represent a quantitative value and avoid ambiguity about whether a given point has been reached. The actual point may represent the measure or value of a given indicator at a given point in time; the value of a derived or aggregated measure or index; or the value of a rate, whether it be the rate or frequency of a given ecological process or the rate of change for the values of a given indicator.

An assessment point's form depends on its purpose. One simple form may be based on time, where annual or other reporting cycles are used as a routine check of indicator values to determine if they meet or exceed values of concern (another type of assessment point). As we indicated, the idea of assessment points does not replace alternative concepts. As such, there may be more than one type of assessment point for a given indicator. For example, a water quality standard may represent one type of assessment point (a legal standard), but others may be used for the same indicator to provide early warning of the impending standard. Similarly, a desired condition may form the basis for an assessment point but be poorly defined or subject to disagreement about the actual value. In this case, assessment points may be used along the trajectory to help refine the definition. Carter and Bennetts (this issue) explore these and other potential purposes in greater detail.

How assessment points are determined

The planning processes used by agencies responsible for managing parks and protected areas generally employ a hierarchical structure that includes a broad mission or vision at a high level, and focuses at lower levels on very specific, quantifiable management objectives or targets in space and time (see also Carter and Bennetts, this issue). How assessment points are determined, and by whom, depends very much on where within this hierarchy they are applied, and for what purpose they are assigned.

It is important to note that assessment points are identified by scientists and managers working together to determine assessments that best fit their particular needs. Except for regulation-driven assessment points, neither policy nor management mandate dictates the frequency or values of assessment points, nor the content of an assessment or potential action. The collaboration between scientists and managers to determine assessment points is, by itself, an important step toward the integration of science and management. Some of the considerations that might go into such a negotiation include:

- Is the assessment point associated with a policy or regulatory standard that requires specific action?
- If the assessment point is based on a desired condition, is that desired condition well defined, or in need of refinement?
- What is the level of uncertainty regarding the resource condition, and how conservative would we want to be in detecting a point of concern?
- If the point is based on a concern about the resource, what are the consequences of overshooting it?
- What frequency, type, and amount of information best fits the needs of scientific validity and the information needs of management?

How assessment points could be used: An example

In 2005, Yosemite National Park completed the *Merced Wild and Scenic River Revised Comprehensive Management Plan and Supplemental Environmental Impact Statement,* which includes indicators and standards for user capacity that could be used in conjunction with assessment points. Ten indicators reflecting the ecological and social values of the river, including water quality (with *Escherichia coli* bacteria as a metric), were chosen. In the Merced River Plan, the standards associated with *E. coli* are "anti-degradation" for each segment and, at an absolute minimum, meet the state and EPA standard for recreational contact (NPS 2005b).

On-going monitoring of eight front-country sites will establish more protective, Yosemite-specific standards (NPS 2006b). Instead of just waiting to see if the standards are reached at some point, managers and scientists could assign a series of assessment points to each standard, along with a list of potential actions that might occur if an assessment indicates that a given condition has been reached. To account for a modest level of variability in *E. coli* laboratory testing, a screening value of 1.3–1.5 times the EPA standard could be used as an assessment point. Because initial monitoring results suggest excellent water quality along the Merced River (NPS 2005c), an assessment point that identifies an increasing trend in colony-forming units (CFU) of *E. coli* would be important. During such an assessment, potential management actions would be considered that would prevent a gradual transition to an undesired state (Table 2).

Why assessment points are relevant to management

For any management option—including assessment points—to be meaningful, we must have some idea of what we want to achieve through management. Whether this is expressed in terms of management objectives, desired conditions, or another form, the important point is that if we don't know our ultimate goal, then it will be virtually impossible to recognize: (1) when we accomplish it, (2) if we are on a right or wrong path, or (3) whether or not our management is effective (see also Carter and

Table 2. Hypothetical assessment points for use with the Merced River Plan.

<table>
<tr><th>Assessment point</th><th>Criteria</th><th>Potential actions
(NPS 2005b)</th></tr>
<tr><td>Increasing CFU before reaching other assessment point (trend)</td><td>Trend moving toward "degradation" (plan standard)</td><td rowspan="7">• Determine if high value is an isolated event or due to sampling error.
• Increase monitoring frequency to determine when E. coli has decreased to a desired level.
• Educate users regarding impacts of activities on water quality.
• Post signs restricting access and providing water quality information.
• Close sections of river temporarily or permanently.
• Restrict or redistribute specific uses (rafting, swimming, etc).
• Expand infrastructure (restrooms, etc.).
• Limit overall number of users through entrance station quotas.
• Reduce/limit stock use in certain areas</td></tr>
<tr><td>50 CFU/100 mL</td><td>Guesstimate of upper range of current condition</td></tr>
<tr><td>150 CFU/100 mL</td><td>Approaching regulatory standard</td></tr>
<tr><td>235 CFU/100 mL</td><td>California and EPA single-sample limit for full-body contact (regulatory and plan standard)</td></tr>
<tr><td>300–350 CFU/100 mL</td><td>Screening value to account for uncertainty</td></tr>
<tr><td>500 CFU/100 mL</td><td>Approaching regulatory standard</td></tr>
<tr><td>576 CFU/100 mL</td><td>EPA single-sample limit for partial body contact (regulatory and plan standard)</td></tr>
</table>

Assessment points could be assigned before degradation occurs, at regulatory standards, to account for uncertainty of the actual value, or to assess the risk of the current trajectory.

Bennetts, this issue). Thus, a key first step is identifying the desirable and undesirable conditions within a management area.

Further, if we realistically expect assessment points to be incorporated into management, then the approach must overcome obstacles that have hindered the use of related concepts by including:

- The capability to cope with the uncertainty;
- The capability to accommodate abrupt or gradual undesirable change;
- The capability to incorporate multiple stressors and/or spatial and/or temporal scales; and
- The flexibility to incorporate a broad suite of values into the management decision process.

Below, we discuss how assessment points are able to meet these and other challenges to linking monitoring to management.

Assessment points cope with uncertainty. Uncertainty in ecological systems is ubiquitous and should not be used as an excuse for failure to take action or to consider a suite of possible actions. However, uncertainty about the precise response to an ecological driver should not be confused with uncertainty about whether there is an expected response to that driver. To use an analogy from human health, most would agree that smoking is unhealthy and can result in cancer, even though we are uncertain about the exact time that cancer is likely to occur. Similarly, the risks of ecological consequences need to be considered even if we cannot accurately predict the exact point at which they might occur. In many cases, there may be early warning signs of a trajectory leading to an undesirable condition. We need to regularly look for these warning signs and evaluate the potential severity and magnitude of the consequences of change.

An important benefit of assessment points is that they provide a means of embracing uncertainty. They also enable us to anticipate undesirable changes with sufficient lead time to enact a management strategy that may reverse or ameliorate an undesirable trajectory early in the process. For example, Figure 6 illustrates a hypothetical threshold that is poorly defined (i.e., with considerable uncertainty about its location). To address this uncertainty, assessment points can be assigned to indicator values preceding the hypothesized threshold, thereby stimulating an examination of all evidence relevant to evaluating whether or not the ecological threshold is impending. Assessment points can be assigned in increasing frequency as the hypothesized threshold is approached (i.e., as its probability of occurrence increases). An adaptive framework promotes the articulation of alternative hypotheses about important ecological processes. A set of assessment points can be implemented to reflect each of the alternative hypotheses as a means to accommodate realistic levels of uncertainty.

Perhaps the most basic form of uncertainty about ecological thresholds in a given system is whether or not they even occur. In a recent synthesis, Lindenmayer and Luck (2005) reported that some studies detected ecological thresholds that were predicted, while others did not. They attributed the diversity of outcomes to both methodological differences among studies and real differences in ecological responses. Similarly, Groffman et al. (2006) suggested that although there is abundant evidence that threshold behaviors occur in many ecosystems, this does not imply that they exist in all systems. The routine use of defined

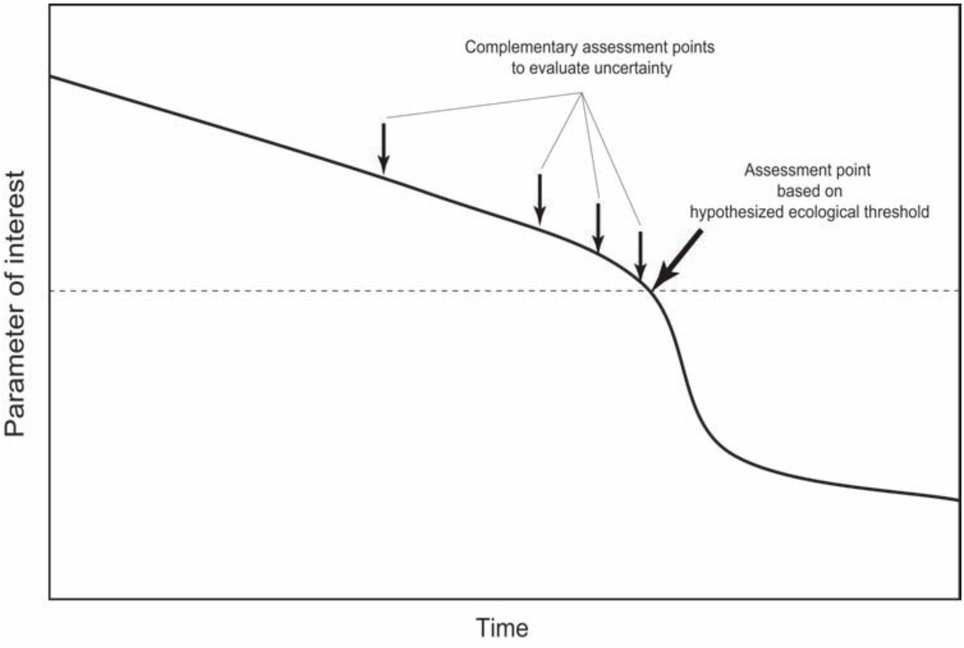


Figure 6. Assessment points can be assigned before a hypothesized ecological threshold is reached in order to account for the uncertainty of the actual value of that threshold or to assess the risk of the current trajectory.

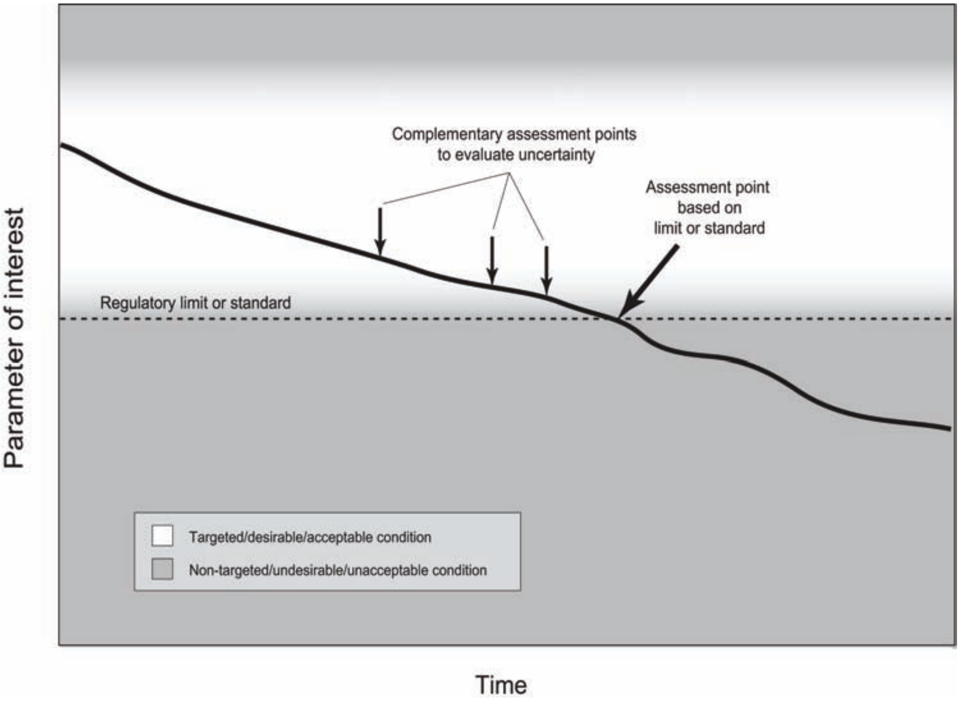
assessment points greatly increases the likelihood that pertinent measurements will be obtained before a system crosses an important ecological threshold. Thus, a key contribution of a formal assessment-point framework can be to help identify, describe, and define the existence of thresholds in a variety of ecosystems.

Assessment points can accommodate gradual and abrupt change. Although most management efforts that have used threshold concepts have emphasized event-driven or abrupt change (Watson et al. 1996; Lindenmayer and Luck 2005), ecosystem responses to stressors can also be slow and gradual (Watson et al. 1996; Rapport and Whitford 1999). Because incremental changes are usually less obvious to observers, an approach that focuses only on abrupt or event-driven change is likely to overlook substantial but slowly occurring degradation (Watson et al. 1996; Lindemayer and Luck 2005). In contrast, assessment points can easily accommodate virtually any type of ecosystem response, provided they have a clear reference to what is considered a desirable condition of the resource or ecosystem. Similarly, there may be consensus that a point exists at which the condition of a resource is no longer acceptable, but disagreement about the precise point where degradation has occurred (see also Carter and Bennetts, this issue). This case is addressed by explicitly defining multiple assessment points along the system trajectory, stimulating the evaluation of criteria to determine acceptability, and determining whether or not those criteria have been met (Figure 7).

Assessment points incorporate multiple stressor effects and multiple spatial and/or temporal scales. Especially when used in conjunction with conceptual models, assessment points can help us to tease out the complex, multiple factors (e.g., stressors, spatial and temporal scales) that may be contributing to change. Conceptual models help to organize our understanding of ecosystem dynamics (Stringham et al. 2003) by identifying known or hypothesized ecosystem stressors (Kurtz et al. 2001; Ogden et al. 2005). They can also help guide our use of assessment points. Say, for example, that an assessment point is based on an ecological threshold related to an abrupt shift in water quality. A conceptual model may identify several indicators of the threshold in question. In this case, evaluation of a cumulative set of indicators may be an explicit part of a given assessment to determine the evidence for an impending threshold. Similarly, an assessment may explicitly call for an evaluation of one or more indicators at one or more spatial and/or temporal scales.

Assessment points can incorporate a broad suite of values. In and of themselves, assessment points do not provide a means for weighting ecological risks against other societal values. However, the process of conducting an assessment at a given point—in contrast to conforming to a predetermined management threshold—offers a simple means of maintaining vigilance over undesirable change, while also permitting the incorporation of alternative values into

Figure 7. Assessment points can be used as a means of evaluating that acceptability along a continuum of change, whether it be gradual or abrupt.



the array of response options at any given point. In fact, consideration of alternative values can easily be included in any assessment.

Assessment points can aid in the planning process. Carter and Bennetts (this issue) describe how assessment points, in combination with an objectives hierarchy, can complement the planning process by helping to link planning, management, and monitoring. They can also help define goals and objectives at various levels of the planning process when such goals or objectives have been otherwise difficult to articulate. Similarly, when the planning process is stalled due to uncertainty, assessment points can play a pivotal role in evaluating alternative options in an adaptive management context, thereby providing a feedback mechanism between monitoring and planning.

Assessment points are financially feasible and responsible. In this age of limited resources, the economic costs of any program—including the implementation of assessment points—must be taken into account, particularly in light of the uncertainty associated with both the risks and the benefits. Here too, assessment points offer a means of balancing costs and risks. If there is little evidence of a detrimental change at a given assessment point, then an assessment may consist of little more than a decision to move on to the next point. This flexibility allows the complexity and cost of an assessment to be scaled to the perceived importance or risk of the particular situation. Addressing potential problems is likely to be less costly if those problems are identified at an earlier stage in their development.

Getting started

Any implementation of assessment points needs to be tailored to the specific needs of a given situation and organization; however, the place to start will typically entail consideration of a series of questions intended to determine three things: (1) what type of assessment points are needed for a given vital sign or indicator, (2) at what indicator values or times assessment points should be assigned, and (3) what should be included in a given assessment. Each of these should be discussed and negotiated initially by an appropriate group of scientists and managers. Appropriate documentation of this process will help facilitate learning from the process as well as to ensure institutional memory of the decisions.

What types of assessment points are needed? Probably the first criterion for determining what types of assessment points are needed is the purpose for which they are being assigned. There will likely be more than one type of assessment conducted for a given situation. If it has not already been determined, a good starting point is to consider what information the indicator or vital sign is intended to convey, and to determine what parameters for the resource would best serve its intended purpose. If assessment points are being used in conjunction with one of the previously described concepts of a point or zone of interest (e.g., standard, desired condition), then that point or the limits of the zone of interest will be one type of assessment point. Additional points could be assigned to provide early warning for that point or zone of concern. If that point or zone is not clearly defined, as may be the case for some desired conditions, then assessment points may be assigned along the trajectory of indicator values to assess the conditions and to refine what is desirable or undesirable. At this point, we might also ask ourselves if there is disagreement about the value of a desired condition. In such cases, rather than the disagreement being a reason to stall efforts, assessment points might be used to help resolve differences of opinion by evaluating resource conditions at intermittent points over time. Again, see Carter and Bennetts, this issue, for more information on types of assessment points.

At what indicator values or times should assessment points be assigned? In most cases, assessment points will be assigned according to both time and indicator values. If a monitoring program has annual or other periodic reporting cycles, then these may serve as a temporal basis for assigning assessment points in combination with actual values of indicators. For cases where the value of a resource indicator has not exceeded a value of interest or concern, then an assessment above and beyond the normal reporting may not be necessary, although this should be negotiated *a priori* (see below). If a point is intended to provide early warning, then it should be assigned based on how conservative that early warning should be. Some managers may want to be aware of an undesirable trajectory long before any concern is warranted; others may prefer to be alerted and consider options only after it is determined that an undesirable condition is imminent.

What should be included in an assessment? The content of every assessment is negotiated from the outset and potentially refined as things progress. As previously discussed and partially articulated in Table 2, assessment may include informing key individuals, evaluating risks of inaction, synthesizing information about potential actions, evaluating complementary indicators, considering supplementary research, consulting with experts, or taking legal or policy-mandated actions.

The simplest case may be an assessment that consists simply of a routine (e.g., annual) report. If the value of an indicator at a routine reporting time is far from a value of concern (as negotiated *a priori*) and the rate of change is not of concern, then the assessment requires no additional action. However, the distinction between an assessment and traditional report is that within the assessment-point framework, the range of values that define "no concern" and the authority to determine that range will have been negotiated from the outset. Assessments that extend routine reporting should also be negotiated, and reflect the information needs and management styles specific to the situation. If assessments are unilateral and forced, they will quickly lose value and interest. Assessments should be adaptive. If they initially take too much time for too little gain, then consider cutting back. In our opinion, assessment points should be viewed as customizing the ways that scientists and managers exchange information for their mutual benefit and the benefit of the resources.

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The Road to Integrating Science and Management: Planning Your Next Trip Using Hierarchical Objectives and Assessment Points

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Introduction

Proper environmental stewardship is a lot like planning a road trip. We generally consider the following things before traveling: "Where do I want to go?" "How do I get there?" "How long will it take?" "How much will it cost?" The same can be true for environmental management. Managers need to plan around goals and consider the consequences of choices that they make. Sometimes they also are required to make quick decisions without the luxury of forethought and planning, just as we might race to the hospital during an unexpectedly early labor. Nonetheless, there are tools (such as objectives hierarchies) to help us plan for crises, while others (such as assessment points) help us navigate the best route along the way.

Before getting into the gritty details of objectives and assessment points, let's carry our vacation-planning analogy a bit further. We can have a very general destination in mind (e.g., somewhere out West), or a very specific destination (e.g., Grandma's house at 1916 Organic Avenue, Bozeman, Montana). Arriving at our desired destination requires different types of planning and preparation, depending on where we decide to go. If we choose the general destination, then there are many possible routes we could follow; all would get us to where we want to be. A trip to Grandma's house, however, would require more detailed planning and navigation. Needless to say, we would never give someone generalized directions to a specific destination: "To get to Grandma's house, just head west." Those instructions might get us headed in the right direction, but more details will be required along the way. An objectives hierarchy functions in much the same manner: broad, overarching goals are defined, and supported with finer levels of detail later, depending on the desired objectives.

Now imagine that we have started our road trip and, unbeknownst to us, someone has removed all of the road signs in North America. It will be much harder to reach either destination without clues along the way to tell us where we are and which way we need to go. If objectives are akin to the travel directions in this analogy, then assessment points are the road signs. Assessment points essentially capture the current condition of a resource (i.e., where you are) and provide perspective on whether that condition is good or bad (i.e., Are you traveling in the correct direction?). In this paper, we discuss three types of assessment points: those that identify desired condition, those that provide early warning ("Slow Down" or "Danger Ahead"), and those that signal imminent loss of the resource ("Stop!" or "Go Back!"). More extensive detail on the definition of and rationale for using assessment points can be found in Bennetts et al. (this issue). The goals of this paper are to introduce the concept of an objectives hierarchy, to identify different types of and uses for objectives, to show how objectives and assessment points are inherently linked, and to encourage the use of explicit, *a priori* objectives and assessment points in natural resource management and planning.

Objectives hierarchies

Key concepts. An objectives hierarchy is an exhaustive set of statements, from a general vision statement to statements of specific, technical objectives, that provides the framework for achieving and maintaining a set of goals. In fact, a complete objectives hierarchy looks like an "inverted tree of goals, branching downward from a value-laden vision statement ... to technically stated ecosystem and institutional goals" (Biggs and Rogers 2003). Each level of the framework describes, in some form or scale, a desired future state or condition of the system, starting with the primary mission, or vision statement. The subsequent levels all feed from that broad foundation and help to establish, in more specific contexts, the goals and objectives that will contribute to achieving the overall mission or vision.

Objectives hierarchies are already commonly used in National Park Service (NPS) planning processes, where tiered objectives, such as those contained within an objectives hierarchy, can connect seemingly disparate documents (Figure 1). For instance, the kinds of broad, value-laden purpose or mission statements found in foundation-planning documents (comparable to the top-tier objectives in a hierarchy) are supported by descriptions of fundamental resources and values. More-specific goals and objectives describing desired conditions for fundamental park resources (comparable to the second-tier objectives) are used in general management plans. Finally, detailed technical objectives and targets (comparable to subsequent-tier objectives) are used for achieving short-term, specific goals, and may be found in resource-implementation or annual plans.

Objectives hierarchies are less commonly used to link management, planning, and science goals. One excellent model that achieves this integration originated in the management plan for South Africa's Kruger National Park (Biggs and Rogers 2003; KNP 2006). There, objectives are expressed as a hierarchy ranging from a broad, value-laden vision of the park's mission to explicitly stated objectives needed to realize this broader vision (Keeney 1992; Biggs and Rogers 2003). The vision identifies key elements that reflect the social needs and values for Kruger, such as biodiversity, human benefits, wilderness, naturalness, and custodianship. In contrast, entries at the finest level of the hierarchy are intended to represent explicit operational targets, ultimately manifested as "thresholds of potential concern" (Biggs and Rogers 2003; see Bennetts et al., this issue), similar to what we are calling "assessment points."

Developing a hierarchy of objectives can be a large undertaking, as one goal of the hierarchy is to capture all levels of detail for existing information. In most cases, not enough information is known to get us exactly where we wish to go (i.e., there are no road signs), but the purpose of the

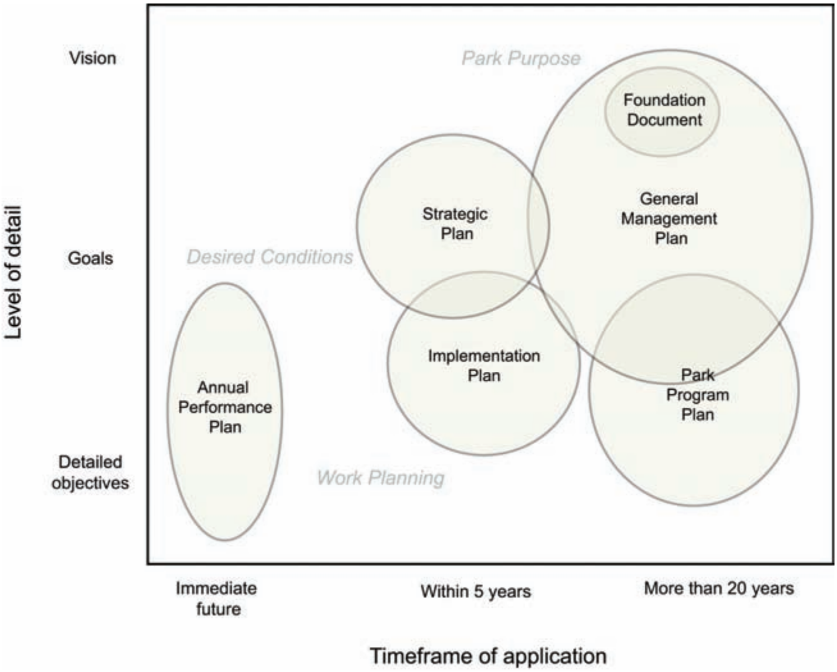


Figure 1. The relationships among NPS planning documents with respect to the level of detail found in objectives, and the intended timeframe. The intended results (shown in gray) are relative to the particular plan being considered.

framework is to help us prioritize objectives and to capture the current state of knowledge. In addition, we do not need to build the objectives hierarchy all at once; the overall strategy can be developed over time. However, because the different components are interdependent, the broader-level components usually must be developed before we can realistically and effectively develop more-specific ones.

Also, although the overall hierarchy has strategic value beyond the sum of its parts, the individual parts have inherent value in and of themselves. Therefore, even if we don't have the information needed to construct a complete and detailed hierarchy, there is considerable value in developing the parts for which we do have the necessary information. Constructing the branches for one component (e.g., biodiversity goals for zone X) may help us to see logical pathways for another (e.g., cultural values).

The National Capital Region example. Figure 2a depicts an abbreviated objectives hierarchy for the National Capital Region Inventory and Monitoring Network (NCRN), fleshed out in Figure 2b to show actual objectives for one example. The overall framework begins with the broad NPS mission to conserve resources and becomes increasingly specific depending on the resource area of interest. While the hierarchy includes several NPS programs (e.g., cultural resources, natural resources, and interpretation), our example (Figure 2b) highlights a specific aspect of natural resources (but see also Hubbard et al., this issue, for application to cultural resources). Objectives become increasingly more technical and detailed as one moves down the hierarchy. It is important to note that the hierarchy is cross-linked at many levels. For example, objectives for forest vegetation are relevant not only to objectives concerned with focal species, but also to objectives for air (e.g., in terms of pollutant impacts), ecosystem (e.g., habitats), and water (e.g., watershed protection). The level of detail is limited by the current amount of understanding.

Distinctions among objectives

Objectives related to planning. Management objectives (e.g., those related to planning) define the desired state, condition, or dynamics of an ecological system, and can be located throughout an objectives hierarchy. A myriad of terms can be used to portray some sense of what we want to achieve in the future (e.g., desired condition, target condition, acceptable condition, management target, management objective, range of natural variability, range of acceptable condition). Unfortunately, different organizations often tend to use the same terms (e.g., "desired condition") in disparate and highly specific ways in their planning efforts. The same terms also can be used differently within an organization when they are related to different scales (e.g., park- or zone-specific). As long as we operationally define our terms so that others may understand exactly how we are using them, we believe that establishing an objectives hierarchy can help us to move beyond semantic differences and toward more strategic thinking, because it helps us to explicitly visualize these terms and the scale within which they are being applied.

That stated, even the most general objectives can be hard to define. To be useful for decision-making, management objectives need to be specific, measurable, achievable, results-oriented, and time-fixed (Williams et al. 2007). Furthermore, regardless of how much time is spent defining and justifying them, management objectives are likely to change as new issues and priorities arise. It is important to recognize that objectives can differ in level of detail, intended time-frame, and primary purpose. Also, each type of objective can inform multiple types of planning (Figure 1).

Objectives related to learning. Monitoring and research objectives (i.e., those related to learning) tend to be more specific than management objectives, and often occur on lower tiers of the objectives hierarchy. Monitoring objectives define the measurements of the desired state, condition, or dynamics (as defined in management objectives). In this context, monitoring objectives directly inform management decisions because the two are linked (Yoccoz et al. 2001). We discuss an example of linked objectives later in this section.

Research objectives help to inform what is not known by promoting learning and understanding about the nature and dynamics of ecological systems. Others have classified these sorts of objectives as "scientific" (Yoccoz et al. 2001). Whatever the classification, these objectives tend to address the "why?" questions, as well as causality: "What is the response?" or "What is the consequence of doing nothing?" Research objectives have the potential to be invaluable to monitoring and management efforts because they help to quantify the significance (i.e., effect size) of important variables.

Research objectives also can be used to evaluate different management options. This is at the heart of what is often referred to as "adaptive management" (Holling

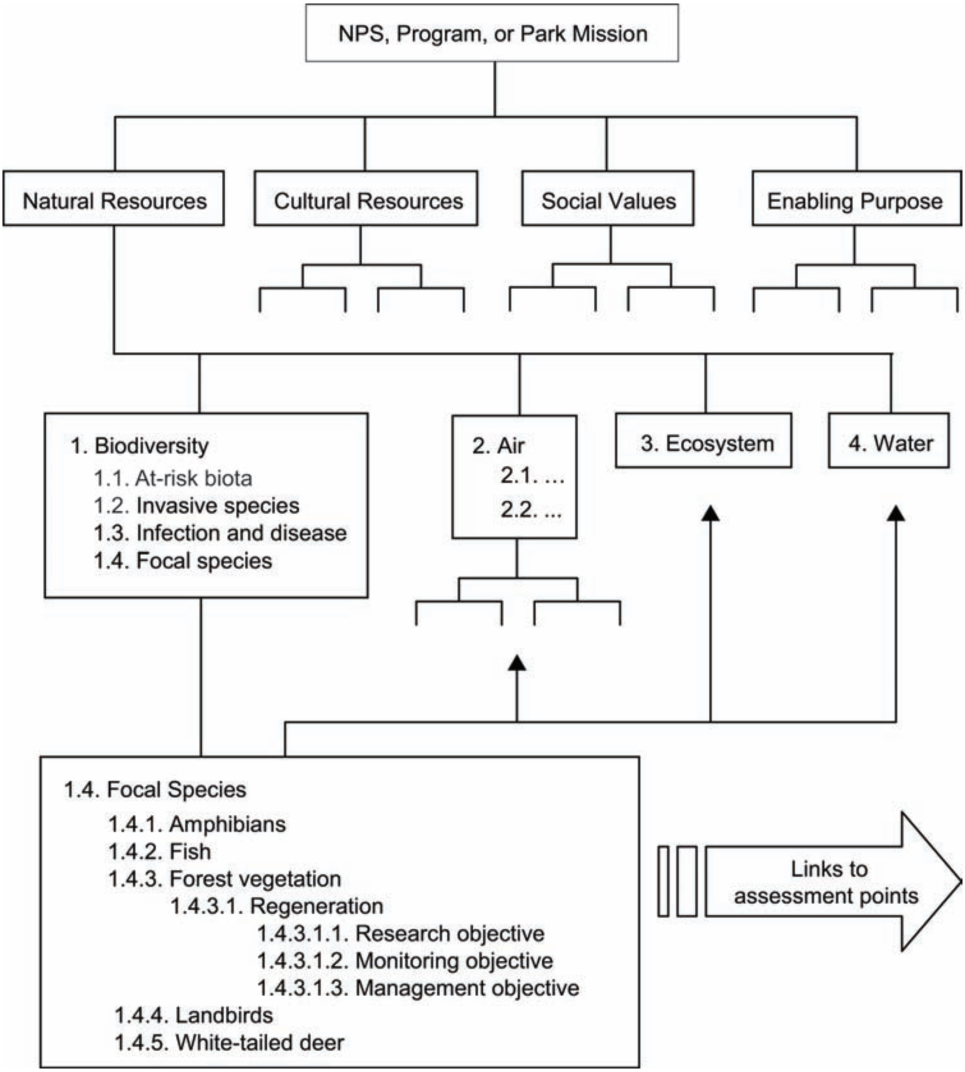


Figure 2a. An abbreviated objectives hierarchy for the National Capital Region based on the framework of Biggs and Rogers (2003). Statements for each level of the hierarchy range from value-laden and general (vision statement) to detailed and technical (objectives).

1978; Walters 1986; Lee 1993; Williams et al. 2007).[1] To do this, researchers apply alternative management actions in a study context in exactly the same way that they would otherwise apply experimental treatments. The intent is to explicitly evaluate the response of these alternative management actions in order to determine which are more effective at achieving management objectives.

Differences of purpose, rigor, and uncertainty. While an objectives hierarchy unifies differences in detail and time-frame, individual objectives can differ with regard to purpose, uncertainty, and rigor (Table 1). Different program areas have different rea-

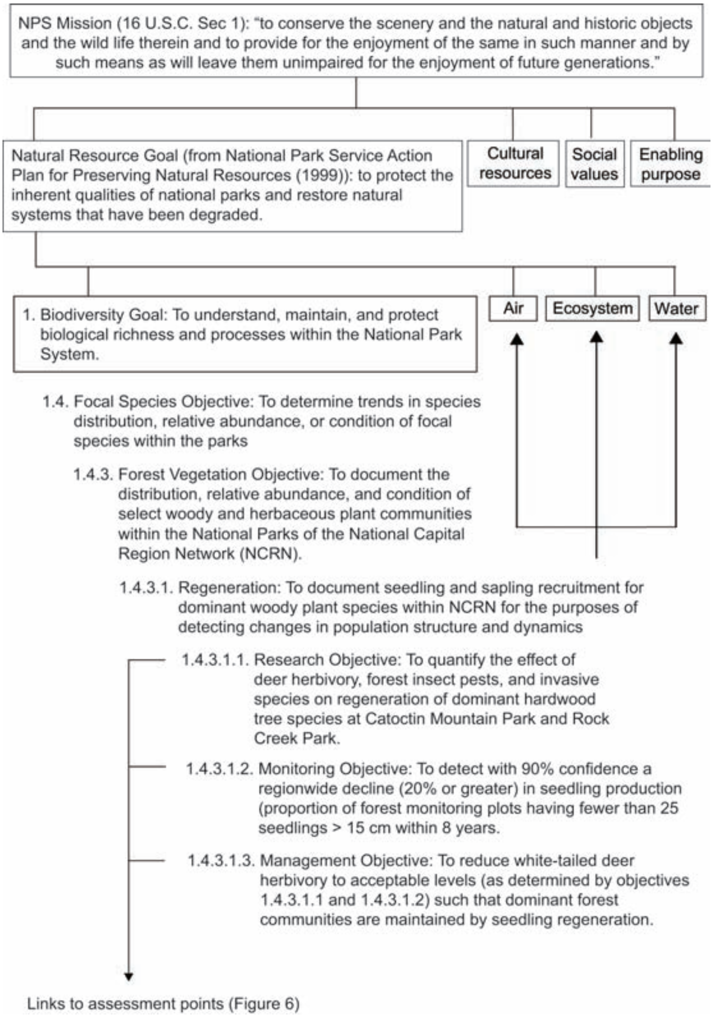


Figure 2b. A selection of hierarchical objectives for seedling regeneration, expanded from Figure 2a. Objectives become more detailed and explicit as one moves down the hierarchy. Note that Management Objective 1.4.3.1.3 is directly linked to the data provided by related monitoring and management objectives. Desired condition, early warning, and impending-loss assessment points relating to the regeneration objectives are shown in Figure 8.

sons for collecting environmental data. Each need may be equally valid and informative, yet how one controls uncertainty and defines an acceptable level of effort (rigor) can be quite different, according to his or her objectives. For example, a program charged with monitoring population abundance for forest insect pests (e.g., gypsy moths) will use objectives and a sampling design appropriate for detecting population trends or rates of change while also ensuring a desired amount of statistical precision. However, a management objective meant to control pest outbreaks, or a research objective meant to examine the implications of an outbreak, each has a different fundamental

Forest-insect Pests		Program areas		
		Monitoring	**Management**	**Research**
Considerations	**Purpose**	Detect trends	Prevent impairment	Quantify effects
	Uncertainty	Statistical "Is it *real*?"	Efficacy "Is it *working*?"	Causality "Is it *meaningful*?"
	Rigor	Survey design	Document actions	Experimentation

Table 1. An example of how particular program areas might consider a particular monitoring indicator. Each program can have fundamentally different, yet equally valid, objectives for collecting and using similar data.

purpose, and requires a different level of rigor, design, and analysis.

Linking management, monitoring, and research objectives. Management, monitoring, and research objectives should complement one another, but are not the same, and are not each defined at every level. The suite of these three objectives shown in Figure 2b illustrates how objectives can be used to gain complementary information. In this example, to best understand regeneration in the National Capital Region, research examines the potential causes of decline (herbivory, insect pests, and invasives). Monitoring documents the current condition and trend of indicator measures (seedlings), and management evaluates actions that use research and monitoring results.

As another example, using stratification and covariates that are meaningful to managers can help to improve monitoring inference. To derive inference for an entire park unit, for instance, all of the areas of that park must have at least some chance of being sampled. Stratification is often used to partition the areas that are more likely to respond similarly to change. If strata relate to management regimes (e.g., planning zones), then additional information can be derived about the effects of those management regimes. Similarly, we can often improve our precision for estimating trends by accounting for some of the sources of variation. For example, bird populations often respond to changes in vegetation; by accounting for changes in vegetation, we improve our estimates of trend in bird populations. When we can connect these sources of variation to management actions, we can derive additional information about the effects of those actions.

How objectives should be used

Strategically and proactively. Objectives are most effective when used within a strategic, forward-looking approach, whereupon the bulk of the work is done up front (i.e., "strategic adaptive management," *sensu* Biggs and Rogers 2003). Strategic adaptive management differs from traditional adaptive management in that objectives are not necessarily linked to specific management actions. Instead, emphasis is placed on increasing understanding about ecological phenomena before action is warranted. The formalization of what is known, or what needs to be known, as early as possible maximizes the window of time for securing funding and garnering support for potential management actions in the future.

A priori objectives can be extremely powerful, do not require a wealth of scientific data, and help us to gain the data we need. When linked to early warning assessment points (see below), *a priori* objectives ensure that relevant data are collected *before* management action is required. The time spent synthesizing information up-front pays dividends later in terms of identifying research needs and collecting monitoring data. Allowing for the maximum window of opportunity in which to collect data improves the quality of the options available when action is required.

To express a hypothetical desired state or condition. How objectives are stated is very important. To return to our trip-planning analogy, people often disagree not about where they want to go (i.e., the desired condition of the resource), but how they want to get there, or whether they can get there feasibly within their logistical or financial constraints. Therefore, objectives that strive to bring about or explain a desired condition should be adaptable and accommodate different paths toward the same end result. Whatever its goals, each objective should be considered as a hypothesis that is open to debate. Treating objectives as hypotheses is essential for refining certain assessment points (see below). Assessment points meant to indicate reaching a desired condition may shift in time and space, which may lead to uncertainty about whether we have achieved our objectives. As we navigate to our intended destination, the negotiation of objectives, desired condition, and assessment points requires a similar negotiation in determining that "Yes, we have arrived."

Historically, the objectives (especially management objectives) developed by agencies within the Department of the Interior have been constructed based on actions, rather than a desired state, outcome, or condition. For example, an objective for fire management might be stated as, "to burn the grassland habitat of a given park every seven years." This objective is fine, if the intent is to account for the activity of park personnel. If, however, the intent of burning is to reduce the encroachment of shrubs, then this objective does little to ensure that result. An alternative objective, expressed as a desired state, might be, "using fire as the primary tool, maintain a maximum of 20% shrub cover on the grassland habitat." An objective expressed as a desired condition provides a much stronger basis for evaluating how well the intent of the action was achieved. Using our trip analogy, adopting an action-based objective would be similar to stating that our objective was to drive, but failing to express where it was we wanted to go.

Cross-linked and iterative. Effective environmental stewardship will incorporate monitoring, management, and research objectives such that they complement and reinforce one another. Monitoring objectives in the absence of management objectives will be of limited value, and building an effective research strategy that will inform management decisions requires having some sense of management goals. If you don't know where you are, then you won't know where you are going.

Assessment points

If an objectives hierarchy expresses where we want go, then assessment points help us to navigate the way. Assessment points are predefined and often negotiated values that signal important changes to the resource being monitored. They can be defined even in the absence of empirical data, and crossing a point does not imply that immediate action is warranted. Assessment points are forward-looking tools that advise us, as in the road sign analogy, when we should pay attention and begin making adjustments (Caution; Slow Down; Stop!). By linking our objectives hierarchy with a series of assessment points, we directly link desired-condition objectives (i.e., those related to management) to learning objectives (i.e., those related to monitoring and research), thereby linking the management, planning, and monitoring functions of the National Park Service.

Assessment points can tell us where we are, which routes makes the most sense given where we want to go, and how long it might take us to arrive. Let's imagine that we can construct a set of objectives that define resource condition along a spectrum, from complete degradation to no impairment. This can be a straightforward exercise if we know what the destination (desired state or condition; say, "no impairment") looks like (i.e., we have been there), which is seldom the case. In the absence of that knowledge, however, we can define points of interest along the spectrum indicating important transitions (e.g., changing from a desired state to a less-desirable one). In this section, we describe three types of assessment points that are useful for natural resource stewardship and planning: (1) points that describe desired condition, (2) points that serve as an early warning, and (3) points indicating imminent loss of the resource (Figure 3). We must make two assumptions when constructing these types of assessment points. First, we assume that we can meaningfully define the continuum from undesired to desired condition (i.e., we have an idea of where we want to go). Second, we assume that we can accurately observe when the transitions occur (i.e., that road signs exist and we can read them).

Data, especially those collected from rigorous monitoring protocols, are critical to the use of assessment points. We can imagine monitoring data as repeated snapshots of ecological condition over time; each monitoring event tells us where we lie along the full spectrum of possible condition. In this context, our status bar provides an upper and lower limit to condition, and monitoring data indicate where we are, where we are headed, and (ideally) how fast we will get there.

Desired-condition assessment points. The first type of assessment points we consider are those that represent the upper bound of what is considered acceptable (i.e., "desired") condition. If these points were road signs, they would read, "Welcome to your destination!" or, conversely, "You are now leaving D.C." Desired condition does not necessarily imply a pristine ecological state. In some instances, it may be impractical or unreasonable to use an ecological standard that may not be reached in the foreseeable future. For example, national parks within urban settings face an onslaught of stressors that are generated outside park boundaries (e.g., polluted air or water entering the park). That is not to say that desired-condition assessment

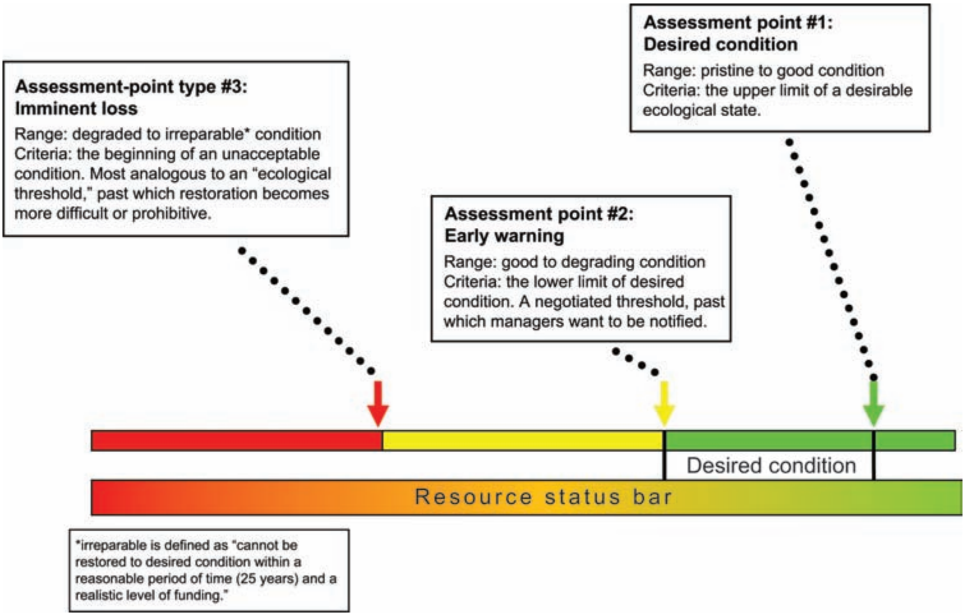


Figure 3. Generalized status bar spanning wholly degraded to pristine resource condition (condition improves moving left to right). Three types of assessment points related to relative condition are shown: (1) desired condition, (2) early warning, and (3) imminent loss.

points do not have an ecological basis in such places; they do. However, a desired condition may be one that minimizes external threats, instead of eliminating them.

The benefit of identifying a less-than-pristine desired condition is prioritization; doing so sets a more reasonable benchmark for restoration and management activities (Figure 4). Setting a reasonable standard for restoration allows managers to shift resources more easily than if they were continually trying to achieve pristine conditions that are unrealistic. It also allows some flexibility in defining the upper limit of pristine when natural and cultural mandates conflict. For example, a historic battlefield park may be required to maintain a cultural setting (e.g., pasture land, fields, small woodlots) that is at odds with an unmanaged community (e.g., an oak–hickory forest; Figure 5). Setting a desired-condition assessment point that is slightly less than ideal allows for such conflicts to exist.

An alternative approach is to use the desired-condition assessment point as a conservative upper limit that may be revised upward as new information is acquired. When scientific evidence is scant or equivocal, it may be more practical to set the upper bound where definitive information exists that is locally relevant—so-called "regional benchmarks." In this context, the desired condition does not refer to the ideal condition of a particular indicator, but to the best condition that exists within a more regionally defined area.

Early warning assessment points. The second group of assessment points is used to signal potentially harmful trends in resource condition. These points are proactive in nature, and are critical because they (1) synthesize current knowledge, (2) gen-

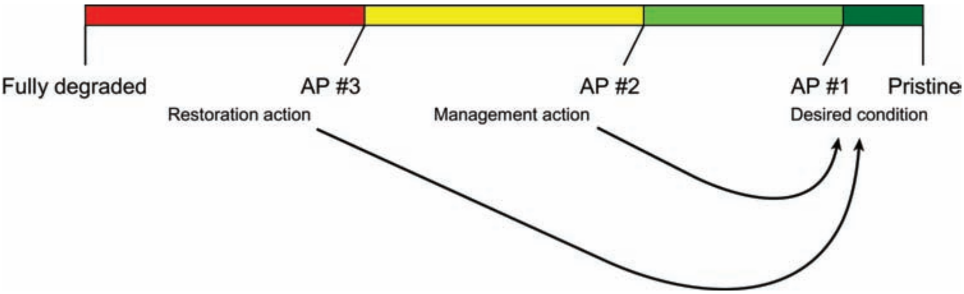


Figure 4. Status bar showing assessment points (APs) as related to management actions. Research that refines understanding of desired ecological condition is prioritized when status is good (above AP #1). Identifying funding options and defining management strategies that mitigate impairment or restore condition are prioritized when condition is declining (moving from AP # 2 to AP #3). Restoration action is required when condition is poor (below AP #3). Assessment point #1 (desired condition) does not necessarily define a pristine state, but rather serves as target for management and restoration actions.

erate a research agenda to refine points, and (3) are the most cost-effective because they are the road signs that say "Slow Down," "Caution," or "Trouble Ahead," allowing managers to take action while restoration is still feasible.

Detection of an early warning does not necessarily trigger management action. What it does trigger is a meeting in which those collecting the data (via a monitoring program, for example) brief those using the data to make decisions (resource managers). "How confident are we with these data?", "How fast are conditions degrading?", "What are the management options?", and "How much could restoration cost?" are all questions that could be addressed during this briefing. We cannot stress enough the importance of using early warning assessment points to get the attention of resource managers; given the wide variety of crises faced by land managers on any given day, early warning points give scientists and managers alike the opportunity to stand back, take a breath, and evaluate the current situation (Figure 6).

Scientists and managers must negotiate early warning assessment points in advance; that is, they must agree about where the points should be located. Regardless of whether a given point will be based on an ecological threshold, a user capacity standard, a desired condition, or some other parameter, scientists and managers need to decide, together, how cautious they want to be, and what degree of assessment will be warranted at a given point. Do managers want to be notified only when a point of con-

Figure 5. National parks meant to preserve historic events may also contain significant natural resources, which often requires managers to balance competing objectives to preserve both natural and cultural resources. Photo courtesy of Tom Paradis.

Figure 6. Invasive species are more difficult to eradicate after they are established, making early detection of outbreaks highly important for managers. Photo courtesy of Tom Paradis.

cern is imminent, or well in advance of any concern? When should a synthesis of the expected consequences be conducted, and conducted by whom? Is there a need to synthesize the evidence for expected responses to alternative management actions? These decisions should all be negotiated and agreed upon between scientists and managers. As a matter of course, early warning assessment points are likely to differ among parks to reflect different resource situations and different judgments of individual scientists or managers.

It should be recognized, from the outset, that a primary purpose of assessment points is to enable more informed decisions. This is most likely to come about when it is done in such a way as to be mutually beneficial. The process of scientists and managers working together to determine what would work best in their situations has the additional value of beginning a dialogue that should help scientists to better understand the information needs of managers, and help managers to play a stronger role in understanding the strengths and limits of the scientific process as well as making the science more relevant to their needs.

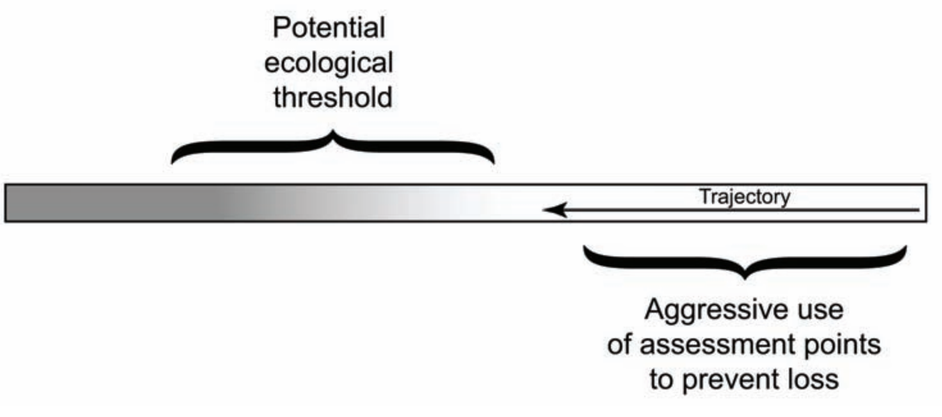
Assessment points used to prevent loss. To many ecologists, assessment points generally evoke the idea of "ecological thresholds" (Bennetts et al., this issue). Of the three types of assessment points described here, those used to prevent loss are most closely related to that concept, because they indicate a fundamental change in the functioning or sustainability of the ecological system. In contrast to other kinds of assessment points, which may represent the bounds of a desired condition or other subjectively defined state, these mark the point of potentially irreversible loss of the resource and, therefore, should be considered as a special class wherein management intervention to prevent the loss or reverse the trajectory is unequivocally warranted.

Unfortunately, these types of points are often the result of complex, non-linear interactions of ecosystem components that are difficult to predict. Consequently, they tend to be retrospective in nature, and are used for crisis management. They signify the breaking point of irreparable loss or impractical restoration (Figure 4). Management options are generally very limited, costly, and tend to be less effective at these points. As such, if the expectation of such an ecological threshold is the basis for these assessment points, then a more conservative and aggressive approach to assessments prior to these points' being reached is warranted (Figure 7), likely requiring more frequent and/or more in-depth assessments when a trajectory is approaching a predicted ecological threshold (i.e., when the early warning assessment points indicate a problem).

Linking objectives and assessment points. In the case of the NCRN, forest management strategies are enhanced by linking different types of objectives to one another using assessment points (Figures 2b, 8). The definition of a desirable state is based upon acceptable ranges of ecological condition, which is defined by the zone between assessment points #1 (desired condition) and #2 (early warning). Monitoring objectives provide status information that informs management objectives. Predefined assessment points are used to inform management decisions about seedling regeneration and the presence of invasive species and insect pests.

If information is not known about a desired range for an indicator, then research objectives (in conjunction with covariates and stratification) explicitly identify assessment points that are needed. In the NCRN example, not enough information is known to define the point at which the occurrence of insect pests causes irreversible harm to the forest community (Figure 8). Research elucidates assessment points, monitoring uses them to provide context for ecological condition, and management uses them to define appropriate management strategies.

Figure 7. A generic resource status bar showing a potential ecological threshold (analogous to assessment point #3). As resource condition for a particular indicator declines, assessment points should be used more frequently and conservatively to ensure that loss does not occur.



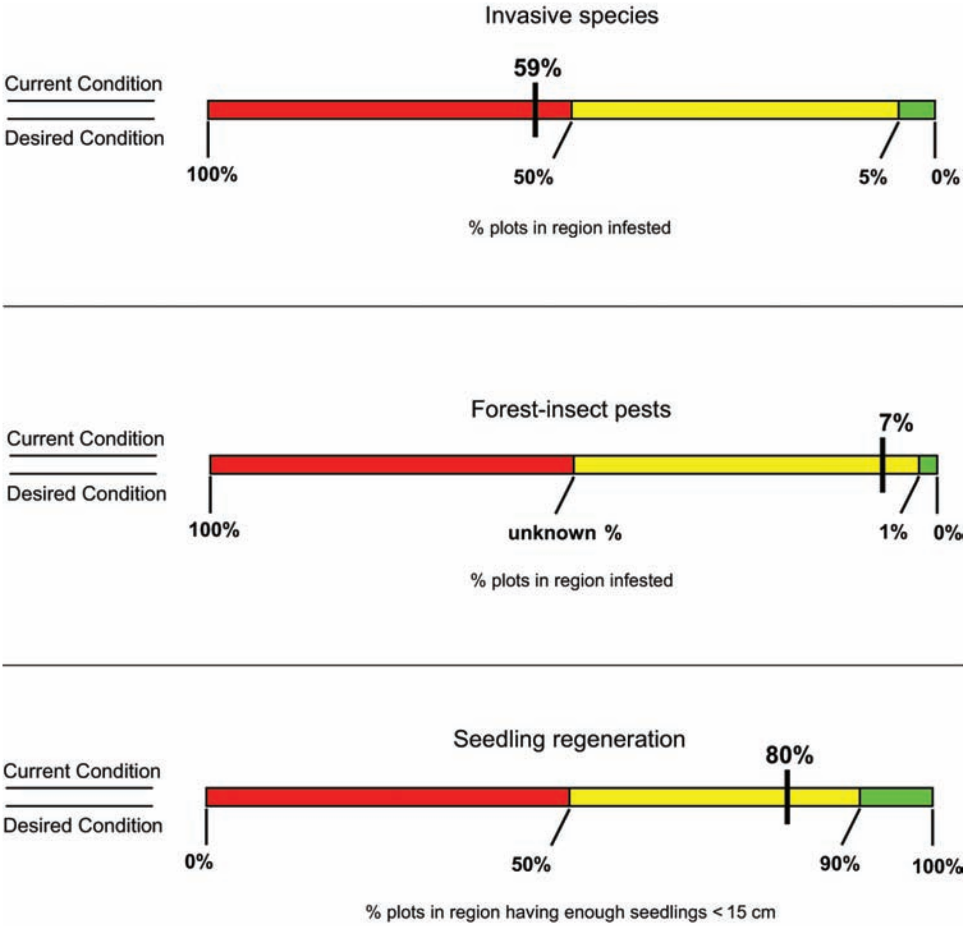


Figure 8. Three status bars used for monitoring indicators related to forest vegetation for the National Capital Region Network, measured in 2007. Current status is indicated above the resource status bar; assessment points related to desired condition are below. A large percentage of plots contain at least one exotic species. Low seedling regeneration (<90%) and high occurrence of forest insect pests (>1%) are of concern when current status is compared to early warning assessment points.

Conclusion

An objectives hierarchy and associated set of assessment points are not unrelated ideas; each improves the other. You can reach your destination with only a road map (i.e., a set of objectives) or by only reading road signs (i.e., assessment points). However, the trip is much easier, and probably quicker, when you have a clear travel plan and navigational aids to guide you.

The ideas we present here are not new; the NPS has established a planning framework that uses tiered goals and objectives (Figure 1), Kruger National Park has shown how thresholds of potential concern (what we call “assessment points”) can be used within an objectives hierarchy (Biggs and Rogers 2003; KNP 2006), and the value of using interrelated objectives is a cornerstone of the adaptive management process

(Williams et al. 2007). Yet, the explicit use of predefined points that define acceptable resource condition, and the process of linking them to planning processes, has not become institutionalized in the NPS. Two new initiatives are taking on this challenge: resource stewardship strategies and watershed condition assessments (please see www.nps.gov/policy/DOrders/draftDO2-1.html; and www.nature.nps.gov/water/watershedconds.cfm [an internet site], and www1.nrintra.nps.gov/wrd/Watershed/index.cfm [an intranet site], respectively]. Our purpose for this paper is to encourage the use of predefined assessment points in all levels of natural resource stewardship planning. Assessment points, when linked to explicit, predefined objectives, offer a consistent framework for characterizing and understanding resource condition. Perhaps a good metaphor for life may also have relevance to the integration of science and management: the journey is as important as the destination.

Acknowledgments

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Endnote

1. The Department of the Interior's definition of "adaptive management," which was adopted from that of the National Research Council (2004), is as follows: "Adaptive management [is a decision process that] promotes flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. Careful monitoring of these outcomes both advances scientific understanding and helps adjust policies or operations as part of an iterative learning process. Adaptive management also recognizes the importance of natural varability in contributing to ecological resilience and productivity. It is not a 'trial and error' process, but rather emphasizes learning while doing. Adaptive management does not represent an end in itself, but rather a means to more effective decisions and enhanced benefits. Its true measure is in how well it helps meet environmental, social, and economic goals, increases scientific knowledge, and reduces tensions among stakeholders" (Williams et al. 2007:4).

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Integrated Resource Management: Applying the Concepts of Rico and Chico to Connect Cultural and Natural Resource Management

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Introduction

Preserving, protecting, and providing unique resources is the foundation of the U.S. National Park Service (NPS), as expressed in eloquent, powerful language in the agency's 1916 Organic Act. For the nearly 100 years of the Park Service's existence, the resources entrusted to our care have generally been partitioned into distinct cultural and natural resource groups for the purposes of park management, with contingent effects on overall resource stewardship. We review the roots of this segregation and propose a new approach for integrated resource management as the second century of national park stewardship draws near. This approach is based on the application of three key concepts described in companion articles in this issue: the evolution of structured *decision-process* and *risk-management* procedures for setting and prioritizing resource management objectives (Marcot, this issue), the development of *hierarchical objectives* (Carter and Bennetts, this issue), and application of *assessment points* (Bennetts et al., this issue) to determine our progress at meeting these objectives.

We focus on NPS because it is the organization with which we have the most experience, and the U.S. federal land-management agency that is most directly charged with simultaneously protecting both cultural and natural resources. However, the approach and issues may be extended to other organizations entrusted with similar responsibilities. The views we express are our own; they in no way represent the formal policy or opinion of NPS.

The false dichotomy of natural "vs." cultural resources

National parks are typically categorized as "natural" or "cultural" resource units based on their enabling legislation, the public profile of the park's resources, and the focus of park management on specific resources within the unit. In 1998, the Natural Resource Management and Assessment Program (NR-MAP) formally identified all NPS units judged to have "significant natural resources" and which were, therefore, eligible for participation in several servicewide natural resource science and management programs. Implicit in this approach was that excluded units were (by default) "cultural parks." However, the vast majority of parks contain substantial (even spectacular) natural and cultural resources, and nearly all park management issues involve elements of both (Figure 1).

Classifying park units as either natural or cultural is both intuitively appealing and deceptively simple—until we consider that historic and prehistoric patterns of settlement, resource exploitation, trade, and warfare generally corresponded to the distribution, kind, and extent of particular natural resources. Today, these natural resources usually persist (albeit influenced by past and present human activities) in and around "cultural parks," and are a critical component of park narratives. From the natural resource perspective, advances in paleoecology and ethnobotany provide clear evidence that human activities have had substantial and lasting consequences for "natural" systems for at least the last several thousand years, even in lightly populated regions of the New World (Delcourt and Delcourt 2004), such as the remote landscapes of the western U.S. that contain most of the acreage of the national park system.

There are few universal truths in life, and exceptions to this composite view of natural and cultural resources certainly exist with the 390-unit park system. Units such as Independence National Historical Park or Denali National Park have very focused resource programs that strongly emphasize one category of resource over another for obvious reasons. Yet even for these unusual exceptions, composite resource management issues do occur and, perhaps more importantly, a balanced approach to resource interpretation and education apply. For example, the kind, extent, and distribution of natural resources obviously played a key role in the establishment of Philadelphia, the thirteen American

Figure 1. The vast majority of parks—such as Tonto National Monument—contain both natural and cultural resources, and management issues often involve elements of both. NPS photo.

colonies, and the rebellion that led to the creation of the United States of America. Wouldn't such detail provide for a much richer public understanding of the significance of Independence NHP and the events it commemorates? By the same token, wouldn't explaining the theory of human-caused megafaunal extinction (Barnosky et al. 2004) provide the visitor to Denali with an enhanced appreciation of the park's spectacular contemporary fauna? Would not the park *and* its visitors benefit from a broader understanding of the rapid effects of human-caused climate change through the visible impacts on Denali's major ecosystems?

Roots of the dichotomy in the National Park Service

If park cultural and natural resources are inherently linked (in most cases), why has the NPS failed to effectively integrate resource management efforts throughout the system? The roots of this problem have much to do with agency culture, staffing challenges, competing and superficially divergent professional disciplines, and the broader challenge of effective integration of science and resource management.

Agency culture. Discipline specialization came relatively late to the National Park Service. Prior to the development of the Resource Careers initiative during the 1980s, resource management was usually a collateral duty for generalist park staff who were engaged in a wide variety of park tasks, from campfire naturalist talks to trail maintenance, fire-fighting to ranger activities. Dedicated resource professional positions were concentrated in very large and high-profile parks, regional support offices, archaeological conservation centers, and university-based Cooperative Park Studies Units. This is in stark contrast to multiple-use land-management agencies such as the U.S. Forest Service and Bureau of Land Management, which had developed (to varying degrees) professional resource management capacity at the onset of agency establishment.

Why would the National Park Service wait decades to make a substantial investment in science and professional resource management at the unit scale, given the agency's challenging mandate and resource-centric mission? Richard West Sellars's (1997) excellent review of NPS natural resource preservation provides numerous explanations; perhaps the most compelling is that there was a commonly held feeling within the Park Service that because the NPS had (1) restricted the kinds and intensity of park use and (2) "fenced out" external human perturbations, science and resource management were largely unnecessary. As detailed by Sellars (1997), this approach was lacking, as perturbations both within and beyond park boundaries have had tremendous impacts on park resources throughout the system. The NPS has recently responded with initiatives to address these problems. New programs such as the Natural Resource Challenge, the Vanishing Treasures Program, Cooperative Ecosystem Studies Units, and Resource Stewardship Strategies seek to improve park management by gathering relevant resource information and improving the direct interface of scientists and managers by placing new science positions out in the field. Not coincidentally, these programs are leading the effort to integrate cultural and natural resources, and to achieve the broader goal of integrating science into overall park management for the benefit of park resources (Soukup, this issue).

Staffing and the divisional structure. With professional specialization came the divisional structure at the park level. Specific functions are currently grouped into hierarchical divisions of specialists, each with a "chief" who answers to the park superintendent. Going by a variety of titles, resource management divisions are commonly dominated by natural resource experts, whereas cultural resources are often lumped in with interpretation or resource protection. Larger parks may contain divisions of both cultural and natural resources (under whatever names); increasingly, many parks are developing integrated resource programs comprising a more-equal mixture of natural and cultural resource experts. While this evolution in divisional structure supports more effective overall resource management, unequal and inadequate staffing levels for resource professionals, and the disjunct nature of the divisional structure, still constrain effective decision-making for complex resource management issues.

"Necessity's mother." "Necessity is the mother of invention" is an often-repeated cliché. Though there are many examples in which this arguably has been the case (e.g., the Manhattan Project), it appears that exactly the opposite is more often true: imaginative inventors create out of inquisitiveness and personal interest rather than serving a specific economic or societal need. Noted ecologist Jared Diamond (1997) terms this phenomenon "necessity's mother," wherein new ideas and technology typically go looking for an application (and where successful application of new technology is itself an accomplishment).

In similar fashion, the identification and prioritization of resource issues at the individual-park scale is often highly influenced by the expertise and interest of the resident staff. For example, if your chief of resources management position is staffed by a vertebrate biologist with a particular interest and experience with bat biology, it is likely that bat research, monitoring, and management will be a major focus of the park. The bat biologist may eventually be succeeded by an archaeologist who shifts the park resource management focus to documentation and preservation of artifacts from a particular period of human occupation—probably a period and culture that she or he knows well, and that attracted that person to the position and park in the first place.

Did the issues or resources change with the position (coincidently), or are personal interests and abilities driving park resource management priorities? Park administrative histories chart the course of which resources are emphasized over time; when compared with an organizational chart of park personnel, they suggest that the latter is often the case. We tend to gravitate towards things we know and like, often oblivious to competing issues with which we are less familiar, or that have not yet been identified. This is not to say that managers have questionable motives, or even consciously move park priorities into line with their own. Rather, when park goals and issues are not clearly articulated, individual expertise and interests ("necessity's mother") can distract and distort holistic resource management.

Cultural vs. natural sciences. Perhaps the greatest barrier to the integration of cultural and natural resource management lies in differences in professional training, particularly academic training. Terms and concepts that are unique to one discipline, or have different connotations among disciplines, restrict effective communication between cultural and natural resource practitioners. Academic programs (particularly post-graduate) tend to focus on increasing specialization from a research perspective. Specialization is required as issues become more specific, but comes at the cost of common terms and concepts. Research, in the traditional sense, plays a critical but focused role in park management, as described in the companion papers in this issue. However, the prevailing views of cultural vs. natural science *research* that have developed within and between these disciplines contribute to their separation in a park *management* context.

Anthropology, archaeology, history, and other subdisciplines of cultural resource management are usually identified with the humanities (cultural sciences) or social sciences, whereas natural resources are recognized as earth and life sciences, sometimes with the sneering insinuation that the earth and life sciences are "real" science. This perception of "soft" vs. "hard" sciences is both commonplace and ironic in the context of the earth and life sciences, as these disciplines often receive the same criticism from physicists, chemists, and molecular biologists (Diamond 1997). The scientific method is often linked to the concept of manipulative experimentation under rigorously controlled environments, and in a fashion that can be repeated (Boorstin 1985). As in the cultural and social sciences, opportunities to apply manipulative experiments are much less common (but still important) in the fields of ecology, zoology, geology, hydrology, and climatology, and are usually multi-factor and not entirely free of potential external bias. As a consequence, the earth and life sciences are forced to rely heavily on observation, comparison, and "natural" experiments to complement their meager opportunities for controlled experimentation (Diamond 1997). Therefore, cultural and natural resource disciplines share many of the same limitations and methods, and both share the overall philosophy of the scientific method, if not its ability to rely on manipulative experiments.

Causality, compelling evidence, and adaptive learning. It is paradoxical that the difficulty of employing manipulative experiments and rigorous statistical hypothesis testing has helped to divide cultural and natural resource management, as classical experimentation is typically not possible, desirable, or required to evaluate most park management questions. For example, to determine the potential effects of rodents on the integrity of prehistoric structures, we might experimentally control rodent populations at varying levels at a series of randomly assigned, identical structures while controlling for external influences (not possible), evaluating any structural damage caused by the treatments (not desirable), and reporting our findings with high statistical precision and carefully worded statements of hypothesis rejection or failure to reject (not required).

We do not suggest that experimentation should not be used to evaluate park management questions. For the previous example, a focused-microcosm experiment using caged rodents and simulated structural material could have revealed important insights, such as what environmental conditions might precipitate damage or what barriers might be effective. Instead, we are making the case that direct causal explanations are not required to facilitate effective decision-making, and that our inability to conduct an experiment does not obviate the need to identify, assess, decide, and (if necessary) act upon a resource issue. We must use the tools that are available and appropriate for the issue at hand, rather than just lament the limitations of those tools.

Given that a full experimental approach is often not feasible or desirable in a park management context, an alternative is an adaptive approach to learning (Checkland 1985; Holtz 2006) and management (Williams et al. 2007). Adaptive management is a systematic approach for improving resource management by learning from management outcomes (Williams et al. 2007). Adaptive management incorporates the experimental nature of the traditional scientific method in that each management action can be viewed as an experimental treatment that can be repeated (replicated) over time.

Such an approach is an iterative process that relies on *compelling evidence* from observation, monitoring, comparison, and natural experiments, unambiguous and structured *decision processes*, explicit management *objectives*, and preplanned *assessments* at each iteration. Each of these components draws on the basic philosophy of the scientific method (Boorstin 1985) by applying critical thinking and relevant interdisciplinary information to resource protection issues (Roux et al. 2006).

Finally, we argue that the primary goals of park management (resource protection) and scientific research (reliable knowledge) are substantially different with respect to risk. For park management, we are most concerned with the risk of resource damage or loss from human activities, whereas science is most concerned with the risk of accepting incorrect information into our paradigms of how things work (be they an aquatic ecosystem or the factors that contribute to the emergence of a complex civilization). We use the remainder of this manuscript to illustrate how these ideas might be used to resolve a conflicting cultural and natural resource issue with the overall goal of minimizing the risk of resource loss.

Application of the concepts: Rodents and relics at Casa Grande Ruins National Monument

Casa Grande Ruins National Monument was established in 1892, to protect and commemorate the most-evident remains of an extensive prehistoric Hohokam agricultural complex in what is now central Arizona. The first national monument set aside to protect cultural resources, Casa Grande Ruins contains the spectacular, multi-level "big house" and archaeologically important trash middens and subterranean ruins, many of which have been excavated and investigated before being backfilled to provide some additional protection of these resources. Unfortunately, there was no equivalent method of protection for natural resources as modern agriculture and, eventually, urban development began to fragment the landscape around the ruins (Powell et al. 2006).

Occurring within the floodplain of the Gila River, Casa Grande Ruins once contained lush mesquite bosque (riparian woodland) and xeroriparian vegetation (Clemensen 1992). Frank "Boss" Pinkley was the monument's custodian (superintendent) for 23 years in the early 20th century, a period that saw the rapid rise of livestock ranching and irrigated row-crop agriculture in the vicinity of the 480-acre monument. Reflecting on the dramatic consequences of these adjacent land uses, Pinkley remarked, in 1924, that the monument would soon be "the only bit of typical desert land in this part of the valley" (Clemensen 1992). Natural resource inventories and interpretive themes were planned and partially implemented (due to funding limitations) as early as the 1930s at this "cultural" monument (Clemensen 1992). When the results of these early efforts are compared with subsequent natural resource investigations, culminating in the vascular plant and vertebrate inventories of 2002, Pinkley's observations do not hold for the present; even the monument's ecosystems have been dramatically altered by land use outside the boundaries (Powell et al. 2006), with implications for both natural and cultural resources.

Burrowing by round-tailed ground squirrels *(Spermophilus tereticaudus)* has resulted in substantial damage to park archaeological resources from the mid-twentieth century to the present (Swann et al. 1994; NPS 1997; Figure 2). As a consequence, concerned park managers have engaged in a sporadic poisoning campaign within the monument for the past 50 years. This effort to curtail a native species that is ubiquitous in the Sonoran Desert (Hoffmeister 1986) has been very controversial, and appears to provide a clear conflict between a cultural resource objective (preserving the ruins) and a natural resource objective (protecting the native biota and ecosystem processes). In the next sections, we will suggest an approach for resolving this conflict at Casa Grande Ruins by applying the concepts presented in this issue.

Developing objectives hierarchies and assessment points for Casa Grande Ruins. The controversy over ground squirrel control at Casa Grande Ruins is less an argument of competing objectives than one of methods. No one argues that the archaeological resources are unimportant or are unaffected by the ground squirrel activity (Swann et al. 1994). Rather, the argument is over the consequences of the methods employed (poisoning ground squirrels and potentially other "non-target" species) and their efficacy at meeting the objective (reducing damage to archaeological resources).

Confounding methods with objectives is a common problem in resource management (Carter and Bennetts, this issue). The park's Integrated Pest Management Plan (NPS 1997) focuses on methods with little discussion of specific objectives, or criteria for knowing if progress is being made toward achieving those objectives. We argue that a clear set of interconnected resource objectives must precede any substantive

Figure 2. Burrowing by round-tailed ground squirrels *(Spermophilus tereticaudus)* has caused extensive damage to archaeological sites at Casa Grande Ruins National Monument. Jim Hughes photo.

discussion of methods, and we propose to develop those objectives using an *objectives hierarchy* (Biggs and Rogers 2003; Carter and Bennetts, this issue).

An objectives hierarchy is "an exhaustive set of statements, from a general vision statement to statements of specific, technical objectives that provides the framework for achieving and maintaining a set of goals" (Carter and Bennetts, this issue). The general vision statement is an expansive depiction of the optimal state of park resources, free of technical jargon and often drawing on a park's enabling legislation. It might be thought of as the ideal two- or three-sentence response—understandable to the lay public—to the question, "Why is it a park?" (i.e., what is it that makes the place unique or important). Flowing from this general statement of purpose is a series of tiered objectives, each of increasing specificity and narrowing scope, which in composite provide the details that contribute to the general park vision.

The general vision statement for Casa Grande Ruins could be derived from the park's purpose as laid out in its enabling legislation: "[the] protection, preservation and care of the ruins of the ancient buildings and other objects of prehistoric interest thereon..." (Presidential Proclamation no. 1470; 40 Stat. 1818, as cited in Clemensen 1992). By incorporating other mission-defining elements such as the NPS Organic Act, NPS policies, and planning documents, we might craft a final vision statement to read something like this: "The purpose of Casa Grande Ruins National Monument is to preserve the extensive prehistoric remnants of a great Hohokam civilization, to understand the relationships between people and land that led to the rise and decline of this culture, and to relate these stories to park visitors" (Figure 3). Note that this vision statement equates the park's purpose to that of a successful public museum: the park preserves and displays the "artifacts" (cultural and natural resources) of a particular theme (the sophisticated Hohokam culture of the 13–15th centuries), actively researches these artifacts to understand the significance of the theme, and effectively communicates this knowledge to an interested public.

Figure 3. The purpose of Casa Grande Ruins National Monument is not only to preserve the extensive prehistoric remnants of a great Hohokam civilization, but also to understand the relationships between people and land that led to the rise and decline of this culture. NPS photo.

Fine-scale, technical objectives lie at the base of the hierarchy (Biggs and Rogers 2003; Carter and Bennetts, this issue). An example of a fine-scale objective might be, "Maintain the integrity of archaeological middens 'A' such that animal burrows (visible on the surface) do not occur within two (2) meters of the perimeter of the site."

The phrase "burrows do not occur within two (2) meters of the perimeter of the site" is an example of an assessment point (Bennetts et al., this issue), which is critical for linking objectives to something we can measure and interpret. If occurrence of any burrows within 2 meters of the site is an unacceptable level of disturbance, or a perceived point of imminent loss, then we would want to prepare or act before this critical level was reached. To meet this need, we would assign additional assessment points to reflect early degradation of the resource (Carter and Bennetts, this issue), and evaluate the state of the resource when those points were reached. In our example, we might set these additional assessment points at 5 meters, 10 meters, and 15 meters, perhaps with some acceptable density of burrows at the farther distances, based on (hypothetical) values in the professional literature, mandated standards, or expert opinion in any combination. An important caveat is that our monitoring techniques must be able to estimate and detect when an assessment point is reached.

Assessments points do not inherently result in a particular management action. Rather, they trigger a planned evaluation process that may result in management action, reconsideration of existing assessment points, addition of new assessment points, or research into potential mitigation techniques (Bennetts et al., this issue). These evaluations may be informal or very formal and structured, such as using decision-support tools (see below), with the latter being more critical as we approach the unacceptable state. Assessment points are also used to define our desired conditions. For example, if management actions reduced site disturbance (burrows) to 10 meters or farther from the site (again, hypothetical), we might consider the burrowing effects to be negligible, and be able to scale back our management practice (e.g., killing ground squirrels).

Use of structured decision-support tools. The advantage of having very specific objectives and assessment points is that they are clear, unequivocal, and measurable. The disadvantage of using fine-scale objectives is that there must be many of them to adequately encompass the resources and conditions defined in the general vision statement (i.e., the more specific the objectives, the more that you need). As a result, the process can devolve into a list-building exercise. The point of an objectives hierarchy is to identify and develop the most important objectives of a park, not to create a long, unordered list of nice things that someone, somewhere, would like to see at the park. It must be decided which candidate objectives will be added to the hierarchy. Objectives in the hierarchy must also be prioritized, as we can't afford to simultaneously manage for everything with equal effort. Potentially conflicting objectives (such as the ones in the original premise for our example) must also be resolved or compromised upon. Finally, the details of each objective and assessment point need to be agreed upon; for example, is "20% disturbed surface area of midden 'A'" too much? Such decisions cannot be taken lightly if the process is to be successful. *Decision-support tools* that emphasize the risk of resource damage and the feasibility of meeting the objective can help us to meet these challenges (Marcot, this issue).

Decision-support tools can incorporate multiple objectives, multiple criteria, uncertainty, and (in some cases) expert opinion (Marcot, this issue). Several decision-support tools have been developed (e.g., analytical hierarchy process, Delphi paneling process, multiple-criteria decision aid, Bayesian belief networks) to address conflict resolution and promote effective decision-making in many fields, including resource management (Marcot et al. 2006). The key features of these approaches are that they (1) seek to reduce personality-driven and "group-think" bias in the decision-making process through structured decision pathways, (2) require *a priori* determinations of multiple criteria with user-defined weighting, (3) address issues of risk (in our example case, resource damage or loss) and feasibility with user-defined standards and probabilities, and (4) effectively incorporate adaptive learning through monitoring and research (Saaty 1990; Holz et al. 2006; MacMillan and Marshall 2006; Marcot et al. 2006; Roux 2006; Marcot, this issue). An implicit advantage to structured decision-support tools is that they require us to document our assumptions, values, and criteria, such that disgruntled participants or external reviewers can track the process from initiation to outcome, even if they do not agree with the outcome. Whereas some managers may fear a loss of control over an issue, or be put off by the apparent complexities of decision-support tools, acceptance of these tools is growing in the resource management community (Marcot, this issue).

By design, adaptive approaches inject the scientific method into the decision-making process. As we have already discussed, cultural and natural resource professionals are familiar and comfortable with the scientific method, and this philosophy can serve as a unifying theme when evaluating resource objectives in a group setting. In this context, the scientific method can be thought of as critical thinking—a curious blend of open-minded, creative brainstorming and enforced cynicism, where a broad array of alternative explanations are weighed against evidence and logic, but no one explanation is wholeheartedly accepted without reservations. This philosophy and the decision-support approaches it evokes allow us to accept uncertainty as being a part of management decisions and to learn and adapt from both research and management outcomes (McDaniels and Gregory 2004). Adaptive learning (Holz et al. 2006) is a powerful tool for evaluating resource objectives and management actions and for making progress on issues that seem intractable; it clearly did not occur in our Casa Grande Ruins example, as the same management actions (principally, poisoning of ground squirrels) were pursued for 50 years without effectively meeting the broadly stated objective.

The progressive addition of new information into the decision-making process through adaptive learning reveals an important truth about the process itself: decision-making is an open-ended, iterative, and dynamic process that will persist as long as the park and the resource protection mandate persist. Adaptive learning allows us to incorporate new information, both from within the park and outside of it, such as management outcomes of new methods, relevant research results, and new policies and laws regarding park resources. The benefits of this adaptive learning process not only guide and improve management decisions, but also inform and refine the actual objectives and assessment points by codifying what is possible and evaluating how effectively resource values were translated into measurable entities.

Concluding the example. So how do these concepts fit our example and serve to integrate cultural and natural resource management in the National Park Service? Consider the likely chain of events that might have transpired if an objectives hierarchy had been developed for Casa Grande Ruins during the early 20th century. We would begin by developing a general vision statement, as described earlier, that clearly emphasized the ancient buildings and other cultural resource elements while still including natural aspects of Casa Grande Ruins, especially as they relate to the Hohokam civilization ("people and land"). The substantial interest in natural resource management and interpretation by early park managers (Clemensen 1992), albeit with few actual funded projects, is evidence that the vision may not be far off.

As each tier of the objectives hierarchy was developed, we would eventually end up with many fine-scale resource objectives related directly to cultural resources, such as the earlier example: "Maintain the integrity of archaeological midden 'A' such that no more than 20% of the surface area of the site contains active animal burrows." Fine-scale natural resource objectives would also be developed through the objectives hierarchy, though they would probably be less numerous and less emphasized than cultural resource objectives. Natural resource objectives might directly address round-tailed ground squirrels (e.g., "Maintain round-tailed ground squirrel populations with 25% of their documented population size in relatively undisturbed areas") or, more likely, address them indirectly through objectives that focused on more holistic issues of ecosystem structure and process (e.g., "Sustain near-surface vegetative cover over 65% of the park area" or "Preserve raptor populations on the park to within 30% relative abundance of reference conditions").

As assessment points were reached first for the relevant natural resource objectives, then the relevant cultural resource objectives, the structured decision-support evaluations would focus effort on mitigating or reversing the undesirable trends for both kinds of objectives. Through the adaptive-learning process, we would refine our objectives, try new approaches and methods, and eventually realize the convergence between our cultural resource problem and our natural resource issue.

If such a focused integration of science and management had occurred following the establishment of the park, then Boss Pinkley's famous forecast of 1924 might have instead been something like, "Casa Grande Ruins will soon be the only typical desert land in this part of the valley, and our science and management efforts provide clear evidence that even the monument's ecosystems are in peril. If we do not act to protect our natural systems, even the Big House ruins themselves might be in jeopardy." Perhaps such a statement, backed by the compelling evidence provided by this approach, could have rallied political support for a park expansion on a scale commensurate with the ecological processes in question. Failing that, this process could provide guidance for best management practices to maintain at least a key subset of the native ecological processes, accepting that the ecological remnants of past systems would mirror the diminished ruins themselves. Finally, the process could at least focus management effort on the successful achievement of the original concern: effective damage control for the most critical cultural resources.

Although the issue at Casa Grande Ruins is real, the application of these processes is hypothetical. However, we have proxy information that provides insights into the causes of the problems and testifies to the interconnected character of cultural and natural resource management. As described, the natural systems of Casa Grande Ruins have suffered tremendous impacts during the past century, as documented by the dramatic differences between the resources observed in the early 20th century and the present (Powell et al. 2006). These data further illustrate a natural system that is extensively modified and now dominated by the land uses surrounding the park. Many of the key predator species and their requisite habitat are now absent or greatly reduced within the park (Powell et al. 2006). Round-tailed ground squirrels have been observed extensively utilizing the surrounding farm fields for foraging while using the park (free of plowing) as "home base," developing a high density of burrows to support their nesting activities (Karen Monroe, pers. comm.). Synthesizing this information in an ecological context, Swann et al. (1994) made a persuasive case against poisoning squirrels to protect ruins, based on their habitat needs. Essentially, Swann et al. (1994) urged the park to protect the habitat and promote ecological processes (e.g., predator–prey relationships) instead of pursuing the hopeless task of treating the symptoms (i.e., rodent overpopulation). We argue that this important conclusion would have been reached much earlier (when the odds of success were greater) if an integrated approach to resource management, based on the concepts presented, had been employed long before the present.

Conclusion

As we approach a new century of National Park Service stewardship, it is vital that we reassess our approaches to managing and protecting the resources entrusted to our care. Our agency tends to view cultural and natural resources and their management in a divided context due to agency culture, history, and perceived differences between the cultural and natural sciences. We argue that this divided view is incorrect, as all parks have, at their essence, a key theme or narrative (i.e., why they're parks) that includes an interlocking mix of cultural and natural resources. The result is that resource protection issues fall along a continuum from purely natural resources to purely cultural resources, with the vast majority falling between the extremes. The example from Casa Grande Ruins illustrates this interdependence; rather than one category of resources impairing the other, as the controversy has been historically framed, the reality is that the extreme impairment of the natural biota and ecosystem processes (i.e., a system "out of balance") has had negative consequences for cultural resources.

By examining resource issues in a larger context, we realize that there is an interconnectedness that demands a re-examination of our decision-making processes. The use of decision-support tools in conjunction with objectives hierarchies makes use of structured decision processes, risk management approaches, and assessment points, and leads to an adaptive-learning process that better informs our methodology and will allow us to enter a new era of more effective resource protection and management. Integrating science into park management is a crucial step toward effective resource protection and interpretation, and it begins with an holistic approach to cultural and natural resource management.

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Comparing Current and Desired Conditions of Resource Values for Evaluating Management Performance: A Cautionary Note on an Otherwise Useful Concept

Robert E. Bennetts and Bruce B. Bingham

Introduction

THE GENERAL CONCEPT OF DESIRED CONDITIONS as the social, economic, and ecological attributes that management strives to attain is well established (IEMTF 1995). "Desired conditions," or "desired future conditions," are terms pioneered by the U.S. Forest Service as part of its planning process in the 1970s and 1980s, but have evolved over time as a result of criticisms and different applications (Leslie et al. 1996). For reasons discussed below, use of the term in a science context tends to imply that desired conditions be expressed specifically and measurably. In the planning process of most resource management agencies, however, the term often implies a more broad description from which more specific objectives are tiered. Still others (e.g., Sutter et al. 2001) advocate that desired conditions be expressed at multiple scales, from broad to specific. In the application of planning processes, the term generally implies a time scale that is relatively long-term (e.g., >15 years); in other applications, such a time scale may or may not be implied.

Consequently, we recognize that "desired conditions" may mean different things to different audiences. However, rather than getting lost in semantics or trying to ensure that we incorporate the multitude of alternative terms and their variations that might apply, in this paper we use "desired conditions" in a more generic context: to imply the desired attributes that management seeks to attain, regardless of the time scale or level of specificity that might be applied in a specific planning or science context.

To further set the stage for our discussion, we need to recognize some elements of the planning processes that are common to multiple agencies. Planning processes generally reflect a hierarchy of goals and objectives, ranging from a broad vision or mission statement down to specific objectives or targets (see Carter and Bennetts, this issue). This hierarchy also typically reflects time scales ranging from long (e.g., into perpetuity) to short (e.g., annual or less). Two additional elements that tend to be intertwined throughout the planning process are goals expressed in terms of desired resource conditions and goals expressed in terms of management strategies or activities intended to achieve those desired resource conditions (Figure 1).

Science plays a major role in helping to

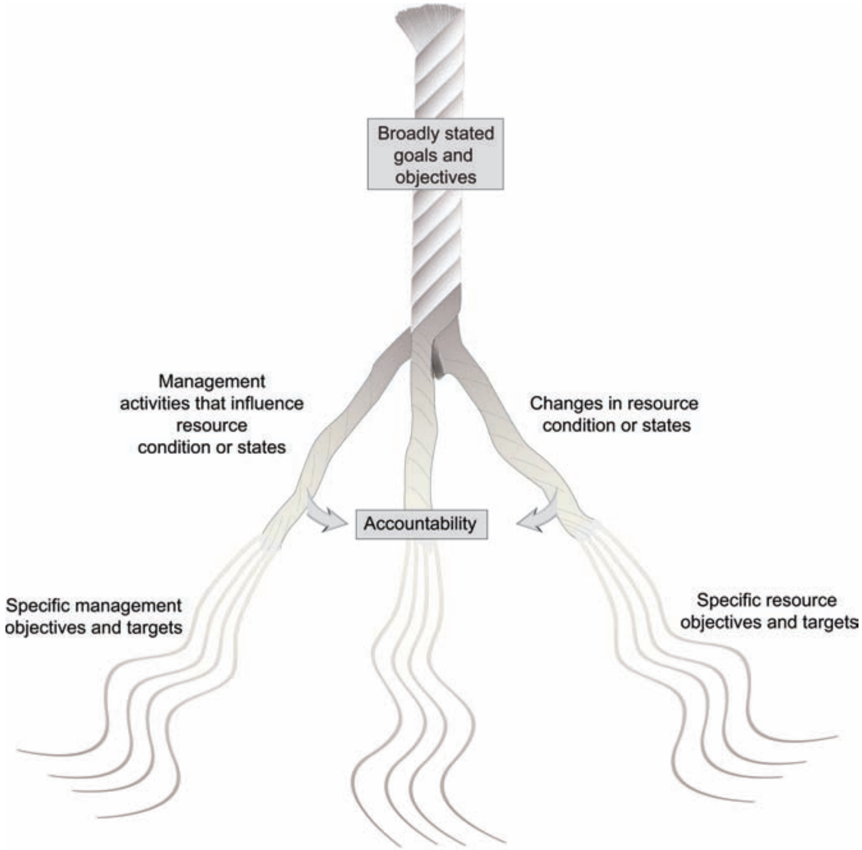

Figure 1. The hierarchy of objectives for resource management agencies (see also Carter and Bennetts, this issue) generally ranges in specificity from broad goals to specific objectives and in time-frame from long- to short-term. Embedded and intertwined within this hierarchy are objectives aimed at the desired condition or state of the resources as well as management activities intended to achieve those desired states or conditions. Accountability for management is integrally connected to both of these elements.

ensure that managers have the information they need to effectively manage and protect resources, and agencies are—and should be—held accountable for managing those resources wisely, effectively, and efficiently. However, unless we are careful about how we treat the relationship between science that informs management and accountability for management outcomes, we may compromise (1) the integrity of the much-needed science that gives us the ability to manage effectively, and (2) the responsibility we have to the public at large for managing those resources effectively and efficiently. In this paper, we describe a potential conflict between the integrity of our science and accountability for our management when that accountability is linked to a system of rewards and punishments.

The scientific basis for comparing current and desired resource condition

The notion of comparing current and desired conditions has a long and solid scientific history; one of the cornerstones of management-oriented science is comparing the current condition of a resource with that which is desired. This is a foundation upon which concepts such as adaptive management are based. A generalization, as well as the origin, of this concept lies in the comparison (i.e., difference) between alternative models. This notion is deeply rooted in sciences such as physics, thermodynamics, and statistics, and has emerged in a variety of theoretical and applied contexts, such as information theory, decision theory, gene sequencing, and economics. Even the well-known chi-square and likelihood-ratio statistical processes are based on the difference between observed and expected values, where "current" condition can be considered what is observed and "desired" condition can be considered what is expected. The practice of comparing current and desired conditions in land-management situations is also widely accepted, perhaps in part because it is an intuitive means of evaluating changes in resource condition and is easily communicated to the public at large.

The punitive paradox

In an adaptive-management context, the comparison of current and desired conditions is commonly used as a means of evaluating alternative management strategies. Thus, at first, the idea of measuring management success by comparing the difference between current and desired conditions would seem a reasonable solution to the need for both management-oriented science and management accountability in parks and protected areas. As indicated above, this approach has a solid scientific foundation as well as intuitive appeal for its simplicity and comprehensibility. Thus, extending its application to accountability for resource managers would seem ideal—that is, if it were not for the resulting "punitive paradox": if the comparison of current versus desired conditions is used as a basis for evaluation of management performance or as a criteria for the distribution of funds, then managers who honestly report increasingly impaired conditions may be professionally punished, and subject their park units to potential budget cuts.

Our concern is based on a very simple principle: *if someone is punished for telling the truth, don't expect them to tell the truth.* In a science context, the relative difference between current and desired conditions is used as a basis to compare alternative management actions or strategies (Figure 2). Consequently, there is no "punishment" for being honest; rather, honesty is a pathway for learning. In contrast, when the disparity between current and desired conditions is used as a basis for evaluating management performance or for distribution of funds, there is a reward for minimizing that disparity (better performance evaluation and/or additional funding) and, conversely, a punishment for a bigger disparity.[1]

This problem arises, in part, because it is difficult to factor in the "achievability" of a desired condition when using it as a measure of performance. Under this punitive paradigm, managers may be penalized for not achieving targets (i.e., desired conditions) that they had no realistic chance of achieving. The following sections describe some factors that might make it highly difficult, if not impossible, for a manager to achieve desired conditions.

Lack of information. When a manager's performance is linked to desired conditions, the evaluation process typically involves two questions: (1) Did the manager commit and implement adequate and

Figure 2. Being able to report changes in resource condition without fear of reprisal is essential to our ability to effectively preserve and manage resources. NPS photo, Virgin Islands National Park.

appropriate (management) resources (including staffing and funding) toward the problem at hand as per any planning or prescriptions for doing so? (2) Was the desired outcome achieved? If management actions were intended to achieve a desired condition over a specified time period, and that condition was achieved, then there is no problem. If the desired condition was not achieved, then there are two likely reasons for the failure. First, the appropriate management resources were not allocated or implemented—a situation for which a manager certainly should be held accountable. The second likely reason, however, is that our understanding of how the system would respond to the management actions was not correct. In this case, where the information necessary for effective management was lacking, we need to ask ourselves whether a manager should be held accountable for failing to achieve something that we lacked the knowledge to accomplish. In other words, additional science, rather than punishment, is probably needed.

Lack of management control. Many of the deleterious changes that are occurring in our parks may be the result of external forces (drivers and stressors) that park managers cannot control. Such things as climate change, upstream or upwind air and water pollution, and land use change all may dramatically influence park resources, but originate outside of the parks. Climate change is an emergent global issue that affects virtually all of our parks and protected areas. Air and water pollution may originate hundreds of kilometers away from parks but still have a dramatic influence on park resources, depending on the flow pathways of air and water. Land use change, such as development, may influence migratory pathways or habitat use patterns of wildlife resources. Similarly, a reduction in permeable land surface due to increased amounts of pavement in an area may alter hydrologic regimes.

Unavoidable circumstances. In some cases, protection of healthy resources, or restoration of degraded resources, may be within the potential control of management, but the ability to achieve those goals is beyond realistic expectations given the circumstances. For example, protection of a given resource may require a level of law enforcement or technology well beyond existing budgets, or the time required for restoration of a fragile ecosystem may require decades or centuries rather than the time between management evaluation periods. In still other cases, ecological thresholds may have been crossed that are irreversible.

Trade-offs based on societal values. In other cases, managers may be in situations that require trade-offs in order to balance natural resource protection and alternative values (e.g., preservation and use; see also Lewis, this issue; Figure 3). For example, snowmobiling in Yellowstone National Park probably has no positive impact on natural resources, but may have a negative influence on natural soundscapes, air quality, visitor experience (i.e., of visitors not using snowmobiles), and wildlife. However, snowmobiling may also have a positive economic influence for manufacturers and local tourism industries, and is a valued recreational opportunity for a segment of the public. Clearly, a true desired condition

Figure 3. Management decisions often need to take into account a variety of values, including ecological, societal, and economic. NPS photo courtesy of Mike Quinn.

would not include increased noise and air pollution or negative impacts to wildlife, but managers often face complex situations in which they are forced to determine the best balance of values, which will, by necessity, result in some shifts away from a truly desired condition of some resources. While managers should be held accountable for the decisions they make in regard to that balance, we question whether they should be held accountable for shifts away from desired conditions when the act of balancing natural and societal values forces them to accept some compromise.

Desired condition or achievable condition?

A seemingly simple solution to the problem of using desired conditions as a yardstick for performance evaluation might be to ensure that desired conditions are achievable. However, the problem is that desired conditions should reflect the state of the resource that we truly "desire" to attain or protect. We would argue that the definition of a desired condition also should reflect the mission of its respective organization—for example, with the National Park Service, to leave our natural and cultural resources unimpaired for future generations. Although some might argue that this idea is just semantics, it quickly transcends semantics as the approach becomes the operational standard for what we aim to achieve through management.

Presumably, from a natural resources perspective, the ideal desired condition would imply an intact and fully functional ecosystem (although such a condition may not be desirable for some cultural resources). Recognizing that such a goal is not likely to be attained, desired condition often ends up being defined somewhere in the gray area between that which is truly desired and that which is attainable (Figure 4). Thus, what was intended as a "desired" future condition often is reinvented as an "easily attainable" future condition. They are not the same, however, and the net result can be lowered expectations and possibly lower achievement of goals.

One of the sad results of this phenomenon is that those who are most honest about real or potential deterioration of park and protected area resources (i.e., who define desired conditions that reflect a truly desired state of a park) can be penalized through performance evaluations, or even by a loss of funding. Under such a framework, the motivation to "cheat" could become overwhelming—not because resource

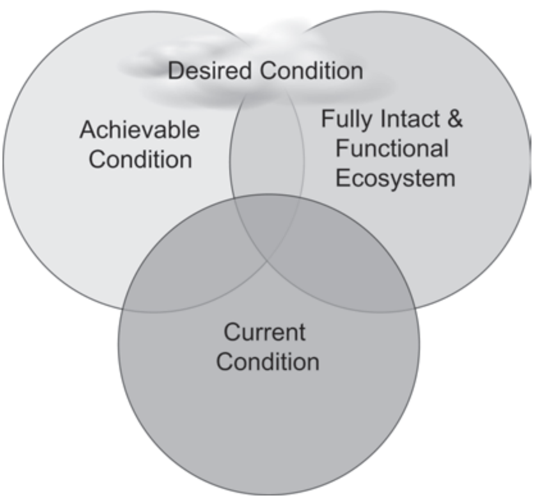

Figure 4. The ideal desired condition for natural resources probably relates to a fully intact and functional ecosystem; however, because such a condition may not be attainable for natural resources, and may not even be desirable for some cultural resources, an alternative usually lies somewhere in a gray area between that which is truly desired and that which is attainable.

managers would willingly trade the condition of resources for their own gain, but rather because a loss of funding is perceived to be even more detrimental to the loss of the resource that they are trying to preserve. Hence, when managers are faced with this punitive paradox, various strategies for protecting their reputations (e.g., against poor performance evaluations) and funding tend to emerge.

Creative semantics as a means of gaining reward or avoiding punishment

One of the most difficult, and sometimes frustrating, parts of implementing a framework based on the comparison of current and desired conditions is actually defining the "desired" condition. We argue that at least part of this frustration stems from the paradox we have described. When it is inevitable that a manager will be evaluated based on circumstances that are not realistically achievable, then several strategies for self-protection may emerge (described below), ranging from consciously trying to circumvent the intended result to merely rationalizing a more realistic set of desired conditions.

Identify fuzzy desired conditions. Setting a clear and concise desired condition is an essential element for sound science. That the clarity of the results will be a direct reflection of the clarity of the initial conception of the problem (in this case, the difference between current and desired condition) is the first principle of study design described by Green (1979) in his book on sampling design for environmental biologists. However, when managers are faced with the prospect of being held accountable, what should be clearly stated desired conditions often are expressed as broad, ambiguous (i.e., "fuzzy") goals. While this outcome is often couched in terms of allowing for "management flexibility," in actual fact it also allows for considerable flexibility in interpreting the results. From a science standpoint, this severely weakens the validity and credibility of the process.

Spin off a subset of "achievable" desired conditions for accountability. Another common strategy is to define an "achievable" subset of desired conditions that will serve to satisfy the accountability requirements while the "real" work gets done outside of that which is generated for accountability. Under this strategy, elements that are difficult or unrealistic to achieve will be left out of any "official" reporting that will be used for accountability. They may or may not be retained within internal documents or plans less subject to scrutiny. The idea is to continue doing the work that is needed, while giving the "bean counters" what they want to see.

Redefine desired condition for success. Fuzzy desired conditions enable ambiguous interpretation of results; however, it is also common for the measurement of success to be defined *a priori*, to ensure that it is achieved. For example, a measure of success such as the number of management units meeting or exceeding desired conditions might be redefined to the number of units showing improvement (for which "improvement" also may be left fuzzy).

Lower the bar. A more extreme version of redefining success is to actually "lower the bar": that is, change the desired condition itself so that it is less difficult to achieve. This is often done in recognition that a truly desired condition is not attainable; thus, a "more realistic" expectation is generated to serve—presumably—as an interim goal.

However, we must also acknowledge that setting expectations too high can lead to lower achievement, if the task of protecting resources is perceived to be inconceivable and managers give up. For this reason, we are not advocating that we abandon the notion of having realistic and achievable interim goals; rather, that we clearly distinguish such interim goals from a truly desired condition (see below).

Resolving the paradox: Do we throw the baby out with the bath water?

It is important to note that these "self-protection strategies" are only necessary when the comparison of current and desired conditions is linked to accountability and/or funding. A German proverb from the 1500s warns against throwing the baby out with the bath water; put another way, "fools who by trying to rid themselves of a bad thing succeed in destroying whatever good there was, as well" (Mieder 2001). Here, we must consider whether the pitfalls inherent in comparisons of current versus desired conditions warrant their being "thrown out" of the accountability process based on the paradox and concerns we have expressed here. In our view, the answer is "no," given their value and utility. However, we do contend that the paradox described here is real, and that it has the potential to undermine scientific credibility as well as the efforts of those who strive to attain high expectations. Thus, in our view, we must find ways to throw out the bath water (resolve the paradox) while hanging onto the baby (striving for both scientific integrity and accountability). The question is, how do we do this?

We believe that to a large extent, this paradox can be resolved by recognizing the pitfalls and knowing the consequences of how planning and decision-making processes treat the distinction between assessments of resource condition and those of performance. Clearly, the planning, monitoring, and performance reporting processes used by the National Park Service and other organizations are designed to support comparisons between current and desired resource conditions. As such, the monitoring and reporting of natural resources management performance must be based on indicators that provide measures of the degree to which a desired outcome has been achieved, as opposed to whether an activity has been accomplished, such as restoring a certain number of miles of stream habitat. This means that the indicators used for evaluating attainment of long-term performance goals should measure the effectiveness of overall management strategies in moving natural resources toward their desired condition, as opposed to necessarily achieving that desired condition within a management evaluation period. Otherwise, comparing outcomes with goals will not be truly informative.

Just as critical as the selection of performance indicators is the description of desired conditions for natural resource values. If the desired conditions are either unrealistic or unsustainable, then managers will never achieve the established goals. Lastly, we need to consistently recognize and be aware of whether we are monitoring or assessing changes in resource conditions, or in the effectiveness of management actions and activities intended to influence those resource conditions. They are not the same, and the consequences of treating them as such may compromise the integrity of both science and management effectiveness—which is clearly an undesirable condition.

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Endnote

1. It is important to note that the concerns we describe throughout this paper do not require a formal system of punishment. Rather, even the perception of punishment is sufficient to generate the responses we discuss.

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Wherein Lies the Heritage Value? Rethinking the Heritage Value of Cultural Landscapes from an Aboriginal Perspective

Lisa Prosper

In this paper I consider how a focus on Aboriginal cultural landscapes might inform how heritage value is conceptualized in relation to cultural landscapes as a form of heritage. I begin by describing how the heritage field tends to conceptualize the heritage value of cultural landscapes largely in terms of material or morphological artifacts. This perspective is commensurate with the field's long-standing concern with the conservation of built heritage, but has several potential limitations when applied to cultural landscapes. Having outlined these limitations, I discuss how the study of Aboriginal cultural landscapes can lead to an alternative way of conceptualizing heritage value centred on the close relationship between culture and place and the dynamic spatial practices and performances through which this relationship is constituted and sustained. It is argued that the alternative conceptualization proposed addresses the potential limitations of a materialist framework and results in an approach to value that contributes to ensuring the continued relevance of landscape heritage to cultural identity.

As Head points out, "the cultural heritage sector uses the classical geographical sense of landscapes as modified by human activity, with an emphasis on ancient monuments and historical buildings."[1] In other words, cultural landscape heritage is generally approached in terms of material or morphological artifacts that constitute culturally determined physical, and therefore visible, modifications to the natural landscape. For example, in the UNESCO World Heritage context, the set of cultural landscapes inscribed onto the World Heritage List reflects a clear preference for cultural landscapes characterized primarily by a unique material or morphological cultural imprint on the natural landscape.[2] This observation is congruent with a recent report on World Heritage activities that highlights the current *materialist* approach to cultural landscape heritage as a significant limiting factor when it comes to identifying, assessing, and designating cultural properties that could contribute to redressing existing gaps and imbalances on the World Heritage List.[3]

Horton notes a similar materialist tendency when she highlights the "uneasy fit" between cultural landscapes and the (U.S.) National Register. Horton argues that the National Register's approach to cultural landscapes is dominated by an "artifactual typology," which locates heritage value in discrete physical entities rather than the landscape as a whole. She further argues that this "artifactual typology" has led to a bias against acknowledging cultural landscapes in which the visible cultural imprint on the land is minimal, absent, or transient (as in the case of many Aboriginal cultural landscapes).[4]

There are several reasons that can help to explain the cultural sector's emphasis on materiality in its approach to cultural landscapes as a form of heritage:

- First, the field of heritage conservation has traditionally been informed by a European preoccupation with artifacts, architecture, and ruins.[5]
- Second, the problematic wedge often driven between "natural" and "cultural" in heritage conservation supports a conceptual paradigm that equates cultural heritage with tangible cultural artifacts or relics such as buildings and monuments, and equates natural heritage with their absence.
- Third, according to Carl Sauer's original definition of the term, a "cultural landscape" is "the material expression of the (seemingly unified) cultural group who live in [a specific] region."[6] Sauer privileges vision and visible forms as the primary way of identifying and studying cultural landscapes.
- Fourth, according to English and Lee, Western scientific approaches to protected area management are often based on the notion that "if we can understand the physical properties and relationships of natural resources, we can manage them sustainably. The assumption lying behind this approach is that the values of these resources lie purely in their physical nature."[7]

In short, a focus on the materiality of landscape as the basis for heritage designation can be attributed to a Western perspective that permeates the conceptualization of cultural landscapes as a heritage construct. There are at least three potential limitations to approaching cultural landscape heritage in this way. The first is the potential for overlooking the heritage significance of sustained interactions between culture and place in which material or morphological forms are largely absent or do not fulfill criteria for designation. This is particularly problematic when it comes to recognizing the cultural landscape heritage of non-material cultures, a point illustrated by the cases of World Heritage and the National Register described above.

The second potential limitation concerns the inability of a materialist or artifactual framework to adequately accommodate the social heterogeneity and plurality of cultural landscapes. Recent academic scholarship proposes that culture is socially constituted according to networks of power and hegemony that are both reflected and reproduced by material and representational landscapes. Indeed, a number of studies employing social and cultural theory regard landscapes as embodiments of the ideologies espoused by particular social actors who possess the power to reflect their image of the world in material or visual form. However, this is not always readily apparent since landscapes tend to naturalize and render invisible the complex social and cultural processes through which they are constituted such that they appear fixed, reified, and inevitable. They work to efface themselves as complex sites of social interaction. In foregrounding the politics of landscape, these studies alert us to the pitfalls of conceptualizing landscape heritage strictly in terms of material artifacts. To do so would run the risk of paving over difference by overlooking the experience of those social actors whose relationship to the landscape is not materially evident. [8]

The third limitation stems from the potential to undermine the dynamic temporality of all cultural landscapes. According to McGlade and others, cultural landscapes are never a finished product, but are rather dynamic, fluid, and historically contingent cultural constructs that are always in the process of being shaped and reshaped, both visually and cognitively.[9] The designation of a cultural landscape based largely on the perceived heritage value of material or morphological artifacts has the potential to freeze it in time and space. This is because changes to the elements on which the designation of a heritage property is based—and this is especially true of built or otherwise engineered structures—are naturally discouraged by the act of designation and the management regimes that follow.[10] Indeed, recognizing only those expressions of the relationship between culture and place that are material in form neglects the myriad cultural practices and performances (quotidian and ceremonial) that are integral to the enduring significance and relevance of place to culture.

For the remainder of the paper I consider how the study of North American Aboriginal cultural landscapes can be used as a starting point for the elaboration of an alternative conceptual framework for approaching cultural landscapes, one that is more inclusive of non-material cultures and less prone to undermining the plurality and dynamic temporality inherent to most cultural landscapes. I argue that the study of Aboriginal cultural landscapes can provide a basis for re-evaluating how the heritage value of cultural landscapes—as a category of heritage—is identified. More specifically, it can encourage an approach to cultural landscape heritage that privileges quotidian practice and ritual performance as the means through which a meaningful relationship between culture and place is constituted and sustained over time and space.

Aboriginal cultural landscapes often lack substantial material or morphological cultural artifacts of the kind used as a basis for defining heritage value in most cultural landscapes. In cases where they are present, visible modifications to the natural environment are often indicative of a broader relationship between culture and place rather than the ultimate expression thereof. Consequently, I would argue that Aboriginal cultural landscapes cannot be approached primarily as material heritage, but rather must be approached first and foremost in terms of an enduring relationship between culture and place that is constituted and sustained through a series of spatial practices and performances. These include such things as: the seasonal use of traditional hunting and fishing grounds, the transmission of traditional knowledge, the telling of stories and oral narratives embedded in place, annual gatherings and celebrations, and the daily inhabitation and negotiation of culturally significant spaces. Such spatial practices and performances transform largely unmodified wilderness into meaningful cultural spaces symbolizing a collective consciousness that is inextricably associated with a geographical territory. Aboriginal cultural landscapes remain relevant as long as they are continually reinvested with cultural meaning through practice and inhabitation, but revert back to wilderness, emptied of their cultural significance, if these cease.[11] They are geographical territories whose cultural significance, and by consequence heritage value, stems from the continuity of a relationship between culture and place that is integral to cultural identity.

Two designated Aboriginal cultural landscapes in Canada offer an opportunity to exemplify the above. Sahoyúé -ˀehdacho National Historic Site[12] commemorates a cultural landscape of the Sahtu Dene and Métis peoples of Canada's Northwest Territories whose oral culture is inextricably linked to the physical environment they inhabit (Figure 1). In this example, "[t]raditional place names serve as memory 'hooks' on which to hang the cultural fabric of a narrative tradition"[13] that relies on the visual, mnemonic role of topographic features (such as mountains and rivers) to assist in the telling and learning of oral history. Through cultural practices which include the use of traditional hunting grounds, story telling and instructional travel, these place names and other traditional knowledge related to the land, are passed on from one generation to the next thereby sustaining the relationship of the people to their land.

Another example can be drawn from Arvia'juaq and Qikiqtaarjuk National Historic Site of Canada which comprises a small island (Arvia'juaq) located near the hamlet of Arviat on Hudson Bay's western shore in Nunavut, and a point of land (Qikiqtaarjuk) immediately opposite (Figure 2). Arvia'juaq is an area rich in marine wildlife and a traditional summer hunting camp of the Paallirmiut Inuit and Qikiqtaarjuk is a sacred site associated with the legend of Kiviuq and contains archaeological evidence of lengthy seasonal occupancy by Paallirmiut hunters. The relationship between culture and place that underpins

Figure 1. Sahoyúé -ˀehdacho National Historic Site, Northwest Territories. Photo courtesy of Stephen Savauge.

Figure 2. Arvia'juaq and Qikiqtaarjuk National Historic Site of Canada, Nunavut. Photo courtesy of Parks Canada.

this cultural landscape is given continuity by the return of the Paallirmiut Inuit to the site year after year and the quotidian and ceremonial practices and performances associated with undertaking this seasonal migration. This continually reinvests the site with meaning as a place where Inuit culture is renewed and reaffirmed.

Ultimately, the study of Aboriginal cultural landscapes in North America can lead to a conceptualization of cultural landscapes (as a form of heritage) that does not rest primarily on an assemblage of material or morphological artifacts. It encourages us to see cultural landscapes first and foremost as a set of cultural relationships to place that are constituted and sustained through spatial practices and performances. These embed meaning in place and give rise to a series of contingent and mutable cultural expressions which can be either material (i.e., built structures) or non-material (i.e., oral histories). However, the locus of heritage value must remain attached to the relationship and the means through which it is sustained rather than the associated cultural expressions, which naturally change over time.

Approaching the heritage value of cultural landscapes in light of the above can help address some of the potential limitations of the materialist approach to cultural landscape heritage discussed above. First, and most obviously, it draws attention to cultural landscapes that are not characterized by substantive visible expressions of the relationship between culture and place. This is important when it comes to acknowledging the cultural landscape heritage of non-material cultures or cultural landscapes where the relationship with place does not result in distinct material or morphological imprints on the land.

Second, understanding cultural landscapes as lived, embodied, and practiced has the effect of politicizing and democratizing what might otherwise be a depoliticized valuation of physical and cultural morphologies.[14] Given the social plurality of cultural landscapes, different groups inhabit the landscapes around them in different ways according to their social position. By affording primacy to the practice and inhabitation of place, it is possible to guard against a "one landscape/one message"[15] approach in which social diversity is masked through a focus on the material heritage of those social actors with the power to project their perspective on the world in material form.

Third, conceptualizing cultural landscapes as a relationship to place underpinned by spatial practice implicitly allows for a measure of change in the expressions of this relationship over time. As stated above, cultural landscapes are dynamic entities which can be frozen in time as a result of heritage designation based on historically contingent material formations. An emphasis on practice and performance draws attention to the dynamic nature of cultural landscapes as an unfixed entity.

In conclusion, the study of Aboriginal cultural landscapes can lead to a reconsideration of the way heritage value is attributed to cultural landscapes. The result of such reconsideration is a shift in the locus of heritage value from material and morphological artifacts to the relationship between culture and place and the spatial practices and performances through which this relationship is constituted and sustained over time. Such an approach allows for change in both the material and non-material expressions of the relationship between culture and place without comprising the relevance of the latter as a cornerstone of cultural identity. Indeed, emphasizing spatial practice over material objects allows for an approach that acknowledges the fluidity with which the relationship between culture and place is expressed over time and through space. This shift in thinking about the locus of heritage value in cultural landscapes is congruent with recent landscape theory, which increasingly privileges practice in the study of everyday landscapes. It is also congruent with contemporary thought on other forms of heritage in the domains of museology, anthropology, and archaeology, all of which have had a long-standing concern with material objects and artifacts, but which have begun to emphasize the critical role of practice in the production of cultural meaning and heritage value.[16]

As Raymond Williams notes, "a culture can never be reduced to its artefacts while it is being lived."[17] Indeed, if one sees heritage conservation as synonymous with cultural survival and vitality, it is important to move away from a material and artifactual notion of heritage toward one that privileges the relationships and practices that give rise to artifacts and other cultural expressions. In the case of cultural landscapes, this means focusing on human relationships with the land and the spatial practices through which they are formed. As Avrami, Mason, and de la Torre argue, the practice of heritage conservation risks losing contemporary social relevance if it maintains an emphasis on the physical conservation of artifacts at the expense of considering the mechanisms and processes through which heritage is constituted and articulated. Thus, it is no longer sufficient to think of heritage "as a static set of objects with fixed meanings," but rather it must be understood as a social and cultural construct "continually created and recreated by social relationships, processes, and negotiations."[18]

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Endnotes

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12. [Editor's note: The superscripted question mark is meant as a representation of the Dene-language diacritic for a full glottal stop at the beginning of a word. The real diacritic looks like a regular-sized question mark, but without the dot. There is no acceptable typographic equivalent short of implementing a special Dene-language typeface. Since that was not practical in this instance, we opted for this representation.]
13. The Sahtu Heritage Places and Sites Joint Working Group, *Rakekée Gok'é Godi: Places We Take Care Of* (Northwest Territories, 2000).
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