Naturalness and Beyond: Protected Area Stewardship in an Era of Global Environmental Change

David N. Cole, Laurie Yung, Erika S. Zavaleta, Gregory H. Aplet, F. Stuart Chapin III, David M. Graber, Eric S. Higgs, Richard J. Hobbs, Peter B. Landres, Constance I. Millar, David J. Parsons, John M. Randall, Nathan L. Stephenson, Kathy A. Tonnessen, Peter S. White, and Stephen Woodley

Introduction

For most large U.S. parks and wilderness areas, enabling legislation and management policy call for preservation of these protected areas unimpaired in perpetuity. Central to the notions of protection, preservation, and unimpairment has been the concept of maintaining "naturalness," a condition imagined by many to persist over time in the absence of human intervention. As will be discussed below in more detail, the goal of naturalness has been codified in legislation and protected area policy and built into agency culture. For much of the 20th century, the adequacy of naturalness as the guiding concept for stewardship of protected areas remained largely unchallenged. Scientists, managers, and conservationists assumed that natural conditions could be preserved and that doing so would assure long-term conservation of biodiversity and ecosystems within protected area boundaries.

In recent decades, however, people have begun to question the feasibility of maintaining natural conditions in protected areas. Growing awareness of Native American influence and recognition of the dynamics of natural systems raise questions about what naturalness even is. And with increasing recognition of the potential effects of climate change, there is a dawning awareness that it may not even be desirable to maintain naturalness. Is the concept of naturalness still sufficient to guide protected area stewardship? Should it be reinterpreted or more precisely defined? Are there other concepts that should complement it or take its place (Box 1)?

In April 2007 we convened a small workshop to explore this question. In this paper, we share some of what was discussed in that workshop. We examine the various meanings of naturalness and why it is increasingly problematic (as commonly defined) as a central goal for protected area management. We detail the case for and against human intervention in ecosystem processes. We explore how naturalness might be redefined or reinterpreted, and how concepts such as ecological integrity and resilience might supplement or replace it. We suggest the need for a pluralistic, adaptive, and flexible approach to protected area management. We conclude by describing some of the ways protected area managers might move forward given current conditions and uncertainties about the future.

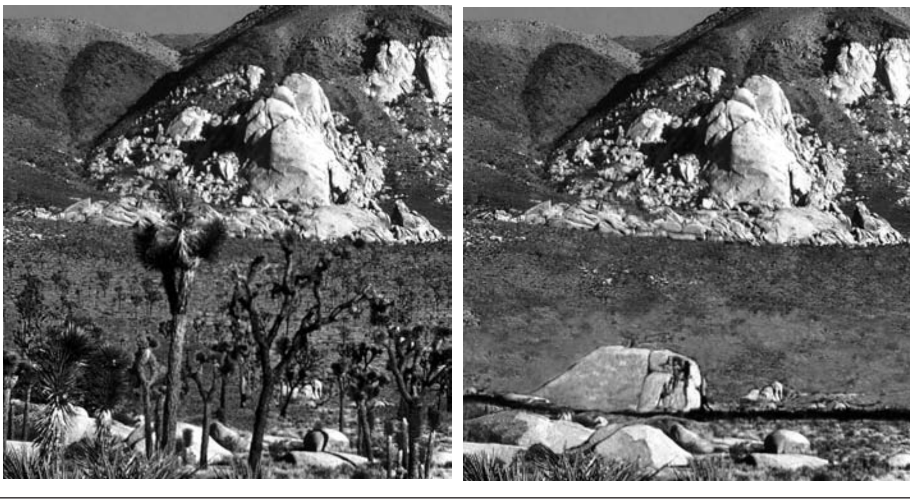
In a world changing as rapidly as ours, clear articulation of goals and objectives is

Box 1. Would a Joshua Tree National Park without Joshua trees be natural?

In a recent attempt to predict vegetation response to future climate change, Cole et al. (2005) reported that Joshua trees may no longer be able to persist within Joshua Tree National Park. While such a prediction is based on numerous untestable assumptions, there is a real chance that Joshua Tree National Park will lose its icon and signature botanical element. This provides a dramatic example of the issues we are raising in this paper. How should the National Park Service respond to this? How does this influence their ecosystem stewardship goals and objectives within park boundaries? And does the National Park Service have an obligation to help secure the future persistence of Joshua trees on lands outside park boundaries?

The primary premise of our article is that the concept of naturalness—which traditionally has guided ecosystem stewardship in parks—is not very helpful in answering such questions. Which of the available stewardship options is more natural: (1) maintaining Joshua trees in the park through artificial means, (2) allowing Joshua trees to disappear from the park, despite the likelihood that this loss reflects modern technological human influence, or (3) actively assisting the migration of Joshua trees to more northerly locations where they are more likely to persist? Decisions will reflect descriptors of park purpose other than naturalness—biodiversity preservation or nostalgia (maintaining park icons) perhaps—descriptors that currently are not clearly articulated in park policy.

Joshua Tree National Park landscapes would look very different without any Joshua trees. Photo courtesy of Richard Frear; Joshua trees "removed" by Suzanne Schwartz.



vital to preservation of park values. The typical response to rapid change is to take action, but action without a clear notion of desired outcomes can be more harmful than inaction. We hope that this paper will catalyze healthy debate about the purposes of parks and wilderness areas now that we recognize how rapidly everything is changing—debate that will lead to clarity sufficient to guide action.

Managing for naturalness

The centrality of naturalness as the guiding principle behind management is clear in the management policies developed to implement the National Park Service Act (1916). The Organic Act declared that the fundamental purpose of the parks is "to conserve the scenery and the natural and historic objects and the wild life therein … unimpaired for the enjoyment of future generations." The policies developed to meet this purpose, from Secretary of Interior Franklin Lane's letter to Director Stephen T. Mather (Sellars 1997), stated that "every activity of the Service is subordinate to duties imposed upon it to faithfully preserve the parks for posterity in essentially their natural state." More recent policies state that national parks will preserve "components and processes in their natural condition," defining "natural condition" as "the condition of resources that would occur in the absence of human dominance over the landscape" (National Park Service 2006). The Wilderness Act (1964) similarly defines wilderness (among other things) as an area "protected and managed so as to preserve its natural conditions." But what does it mean to preserve natural conditions and manage for naturalness?

One sense of the word "natural" refers to everything other than the supernatural (Rolston 2001), so we need a more restricted definition when thinking about park and wilderness stewardship. Most commonly the natural world has been contrasted with the human-dominated world. In this sense, two related characteristics of naturalness are a lack of human effect on ecosystems and a lack of human control of ecosystems (Table 1). Interwoven with this has been the notion that natural ecosystems are stable, self-regulating, and equilibrial. Another commonly perceived characteristic of naturalness, then, has been a high degree of historical fidelity (Higgs 2003): natural ecosystems should appear and function much as they did in the past. This has led protected area managers to use past conditions as benchmarks for the future.

These meanings reflect scientific and societal assumptions about ecosystems that persisted for much of the twentieth century. The idea that North American ecosystems had been stable for long periods of time prior to European settlement dominated conservation discourse. Native Americans were believed to have had little, if any, role in shaping these ecosystems. Protected areas were assumed to be large enough to sustain themselves over time, so it seemed possible to preserve the ecosystems and species currently occupying protected areas simply by avoiding commercial exploitation and development. Little intervention in the biological and physical processes of protected area ecosystems should be necessary. Maintaining naturalness would simultane-

Table 1. Common traditional meanings of naturalness.

- Not affected by humans
- Not controlled by humans
- Stable, self-regulating, and equilibrial
- High degree of historical fidelity

ously meet such diverse goals as conserving biodiversity, maintaining vignettes of primitive America (Leopold et al. 1963) by keeping ecosystems relatively unchanged over time, and respecting nature's autonomy (Ridder 2007) by avoiding intervention.

Naturalness challenged

The adequacy of naturalness as the guiding concept for park and wilderness stewardship has been challenged as protected area goals have evolved, scientific knowledge has improved, and the sphere of human influence has gone global. Initially, national parks were largely about scenery and spectacle (Graber 1983). Management emphasis revolved around nostalgia—keeping things the way they were—and aesthetics. Managers were not reluctant to actively manage for this purpose—from feeding bears to shooting coyotes and wolves. Scenery, spectacle, and aesthetics remain worthwhile park pursuits. But over the past century the list of park values and purposes has grown.

The Leopold Report (Leopold et al. 1963) called for active management (restoring or maintaining disturbance and successional processes) so that "the maintenance of naturalness shall prevail." Management policies also emphasize intervening as little as possible in biological and physical processes (National Park Service 2006), reflecting new appreciation for a value that Ridder (2007) calls respecting nature's autonomy. More profoundly, the conservation of biological diversity has become a core goal for parks and wilderness, with the definition of biological diversity expanding to include preservation of genetic diversity, species, plant and animal communities, the fundamental physical and biological processes which organisms depend on and which structure communities, as well as rates of natural change (National Park Service 2006).

With increased complexity in park values and purposes comes increased conflict between those values and purposes. Managing for some of the meanings of naturalness negate other meanings. In contrast to mid-20th-century beliefs, we know that natural ecosystems are highly dynamic (Wu and Loucks 1995). Therefore, if we are to allow for the free play of natural processes, including evolutionary change, we cannot expect future park landscapes to look like they did in the past (White and Bratton 1980). To some degree we must choose between aesthetic, nostalgic park values and certain ecological values. We have learned that many so-called natural park and wilderness ecosystems in North America have been profoundly affected by indigenous peoples, particularly through burning and hunting (Kay 1995; Mann 2005; Pyne 1997). Past human influence has not been profound everywhere (Vale 2002). However, in many parks and wildernesses, if we are to conserve native biodiversity, it will be important to maintain some past human influences. We must give up the notion of natural park ecosystems as being unaffected by humans.

We have also learned that even the most remote park and wilderness ecosystems already have been and will continue to be affected substantially by modern human activities (Cole and Landres 1996). Again, the magnitude of influence—past and future—has been variable. But in many places, conservation of native biodiversity will compel us to actively manage ecosystems, compromising our interest in respecting nature's autonomy by avoiding intervention.

In short, it is increasingly clear that naturalness is no longer the umbrella under which all protected area values comfortably sit. We must choose among protected area values and among the traditional meanings of naturalness. In particular, we must confront the dilemma of intervention. Then we must articulate desired future conditions for park ecosystems in terms that carry greater clarity and specificity than traditional notions of naturalness (Figure 1).

The dilemma of intervention

Given that human activities are altering park and wilderness ecosystems, the first decision protected area managers face is whether or not (or under what circumstances) to intervene through active management. Much of what we call intervention and active management involves ecological restoration—"the process of assisting the recovery of ecosystems that have been damaged, degraded or destroyed" (SERI 2006). We use the more generic term "intervention" to include any prescribed course of action that intentionally alters ecosystem trajectories and to avoid the connotation of a return to past conditions. In many cases, redirection might be a better term than restoration. Interventions range from lighting fires to culling ungulate populations, from thinning forests to assisted migration of individuals or species better-adapted to changing conditions. Some are one-time actions, such as introducing a species and stepping back to see if it can thrive in a new

Figure 1. Landscapes dominated by open-grown, old-growth pines, like these in Kings Canyon National Park, have been characterized as aesthetic, nostalgic, anthropogenically structured, and high in ecological integrity. Are such landscapes natural? Do we increase or decrease naturalness by actively restoring forest structure using management ignitions and/or mechanical thinning? Is a forest thinned by wildfire more natural than one that is thinned mechanically? Photo courtesy of David Parsons.

site. Others are ongoing, such as liming water bodies to mitigate the effects of acid deposition (Figure 2). Some interventions are small in scale (e.g., actively maintaining a ten-acre sequoia or Joshua tree forest at a location no longer ideal for the species) while others might be large in scale (e.g., burning tens of thousands of acres each year).

In making decisions about whether or not to intervene, the concept of naturalness offers little guidance. Since naturalness implies both a lack of human effect and a lack of human control, one of the meanings of naturalness will be violated whatever is done—or not done (Sydoriak et al. 2001). Decisions must be made using some other guidance, most often a choice between the values of preserving biodiversity and respecting nature's autonomy—to use Ridder's (2007) terminology. Protected area managers can deliberately intervene in ecosystems to restore them, to maintain current systems (resist change), to conserve specific aspects of biodiversity, or assist in their transformation to perhaps better-adapted systems (for example, in response to climate change). Box 2 provides an example of intervention for the primary purpose of conserving regional biodiversity (and recreational opportunities) at the expense of pre-European conditions.

Figure 2. In the Saint Mary's Wilderness, Virginia, atmospheric pollution has lowered pH so much that native invertebrate and fish populations are substantially reduced. In response, a helicopter has been used to dump limestone sand adjacent to creeks. This treatment, projected to be repeated every 5–8 years, raised pH levels as well as taxa richness and the population of native invertebrates and fishes. Photo courtesy of Steven Brown.

Box 2. Assisted migration into designated wilderness: Biodiversity conservation trumps naturalness

Recently, in the Bob Marshall Wilderness, Montana, stewardship decisions have been made that some might consider inconsistent with wilderness. These decisions condone assisted migration—helping species relocate to places where they are more likely to persist—and they place more importance on species conservation than on naturalness. The decisions pertain to management of fish populations in about 20 lakes in the Bob Marshall Wilderness that historically were fishless but that have been stocked with non-native trout for many decades. The plan—approved but not yet implemented—is to remove all non-native trout from these lakes. Then, rather than leave the lakes fishless as they originally were, they will be stocked with genetically pure westslope cutthroat trout. These lakes, which fish are unable to migrate to themselves, offer a refuge from other fish that hybridize with westslope cutthroat and pollute them genetically. Wilderness provides the most inviolate refuge and, therefore, is considered necessary to the preservation of this species, even though the requisite action compromises naturalness.

Historically fishless lakes in the Bob Marshall Wilderness, Montana, will be used as refuges to preserve genetically pure westslope cutthroat trout. Photo courtesy of David Cole.

This situation is complicated by states' rights issues. This intervention, pushed by the Montana Fish, Wildlife and Parks Department, would almost certainly not have been proposed if the species at risk were not a game species. Nevertheless, it illustrates the potential to give precedence to a conservation goal other than preserving natural conditions, even in wilderness. It also illustrates the potential to use techniques like assisted migration, despite the degree to which they seem like "playing God."

Or managers can choose not to intervene and allow ecosystems to adapt and change as they will, absent human intention. This, of course, is also a deliberate and intentional management decision, with very different outcomes than active management. Some of the language in the Wilderness Act—where wilderness is defined as a place "where the earth and its community of life are untrammeled by man"—argues against intervention. To be untrammeled, a place should not be intentionally controlled or manipulated for any purpose, even the conservation of biodiversity (Cole 2000). National Park Service policy is more amenable to intervention, stating that intervention in natural biological or physical processes will be the exception not the rule, but that it is appropriate "to restore ecosystem functioning that has been disrupted by past or ongoing human activities" (National Park Service 2006).

Workshop participants agreed that protected area managers will need to operate across this entire spectrum from non-intervention to active transformation. There was general agreement that it was best to intervene only when necessary and that the threshold for intervention should be particularly high in wilderness. Wilderness lands should be managed with a light touch—with restraint and humility. They have particular importance as "controls" within a landscape of more actively managed landscapes. But there were divergent opinions about how widespread non-intervention strategies should be and the criteria for deciding whether or not to intervene. The concept of naturalness does not provide clarity regarding criteria and thresholds for intervention, so better guidance must be developed. We agreed that the need for intervention increases:

- As protected area size decreases (small protected areas are less buffered from human influence);
- Where pre-settlement influence was substantial and as current human influence increases (adverse effects are pronounced);
- As the social value of attributes increases (more valued entities are at risk); and
- As the scale of stressors increases (impacts are widespread, as in fire suppression or climate change).

However, we also noted that although interventions may be particularly beneficial where stressors are operating at large scales and affecting highly valued attributes, interventions in such situations are also particularly risky. The costs of failure (like the benefits of success) are high because the values at risk are so large and the effects are so widespread.

Desired outcomes of interventions

Decisions to intervene in park and wilderness ecosystems should be based on goals (White and Bratton 1980) and the desired outcomes of interventions should be made specific in the form of operational objectives and targets that identify "what should be preserved" (which elements and processes) and "in what state" (Christensen 1988). NPS *Management Policies* (2006) state that decisions to intervene must "be based on clearly articulated, well-supported management objectives." This is where the ambiguities and divergent definitions of naturalness are most problematic—where the guidance it provides is particularly insufficient. Objectives and outcomes need to be knowable, attainable, and desirable. By most definitions, naturalness has few to none of these attributes.

What is natural is not knowable because ecosystems are dynamic (White and Bratton 1980). To set intervention targets, change must be parsed into natural change and unnatural change. The concept of historical or natural variability has become a popular means of accounting for temporal variability when developing target conditions for managed lands (Landres et al. 1999). For parks and wilderness, the implication is that restoration is likely to be required if current conditions lie far outside the range of natural variability (Franklin and Aplet 2002). But how far is too far?

Paleoecologists have simultaneously advocated that historical data inform management but cautioned that such data should not be used as targets for the future. Ecosystems are unique in time and space, so it is seldom possible or desirable to return them very precisely to a former state (Gillson and Willis 2004). Millar and Brubaker (2006:331) argue that:

> Predisturbance or pre-Euro-American impact conditions are used routinely as reference models or desired targets for ecological restoration. This assumes, however, that climate hasn't changed between the historic target time and the present and that human influence hasn't confounded historic conditions. These assumptions are tenuous, and the likelihood of their validity decreases with time between the historic target and present.... Long-term confounding of human with nonhuman influences challenges use of historic conditions as models for pristine or natural conditions in restoration.

Long-term historical data may be more useful in determining where thresholds have been exceeded than in defining the desired outcome of a management intervention (Willis and Birks 2006).

Natural conditions are not attainable given the ubiquity of human impact. Climate change provides the best example, but the prevalence of invasive species provides another. Future climates that have no analogue will be reflected in no-analogue ecosystems (Fox 2007). We can reinterpret or redefine naturalness to accept substantial ongoing human impact, but what guidance is there for decisions about which types to accept and how much is too much? NPS *Management Policies* (2006) direct managers to "maintain the closest approximation of the natural condition when a truly natural system is no longer attainable." But this traditional approach is problematic because past and even current systems may be unstable under future climatic conditions (Harris et al. 2006). Near-natural conditions may be undesirable and attempting to restore them may be counterproductive. In light of the pervasive global changes that are occurring, Stephenson (2005) suggests that "the NPS and similar wilderness management agencies need to reexamine their missions"—perhaps focusing on "maintaining native biodiversity, even if community structure and composition are no longer natural."

Beyond naturalness

Workshop participants generally agreed about these concerns with the meanings of naturalness and that varied interpretations of the concept can lead to inconsistent and, possibly, inappropriate management. However, opinions about how to respond varied. Some participants advocated reinterpretation of the term "naturalness" to reflect new ecological understanding and the realities of global change. While they recognized a need for more precise and consistent definition (Landres et al. 1998), they felt that naturalness continues to provide a useful goal for park and wilderness management—an ideal to strive for—a constraint to the range of interventions that might be attempted in the absence of a foundation in historical fidelity. They valued the emphasis that naturalness places on conservation of native, indigenous elements and processes and on systems that are dominated by nature as opposed to humans. Other participants felt the concept was fatally flawed and should be replaced. Whether a supplement to or a replacement for naturalness, there was widespread agreement about a need for conceptual guidance beyond the notions of historical fidelity and a nature-dominated world that are inherent to the concept of naturalness. Two concepts explored during the workshop were ecological integrity and resilience.

Ecological integrity

The concept of ecological integrity has been advocated as a goal for ecosystem stewardship for decades (e.g., Frey 1975). Ecological integrity implies wholeness, completeness—the presence of all appropriate elements and processes operating at appropriate rates (Angermeier and Karr 1994). Ecological integrity appears to be a desirable attribute for park and wilderness ecosystems and seems largely consistent with the implications of natural ecosystems. Indeed, some have defined integrity as the ability to support a community of organisms "comparable to that of natural habitat of the region" (Karr and Dudley 1981). Others reject such a simple definition, suggesting that integrity is context-dependent, varying with scale, with hierarchy, and particularly with societal values (Kay 1993).

In 1988, the Canada National Parks Act replaced the notion of "natural" as a management endpoint with the concept of ecological integrity, legally defined as "a condition that is determined to be characteristic of its natural region and likely to persist, including abiotic components and the composition and abundance of native species and biological communities, rates of change and supporting processes." With ecological integrity as the goal, Parks Canada emphasizes retention of native ecosystem components. Biodiversity, ecosystem function, and stressors are carefully monitored. One of the key implications is that active management will often be required to maintain or restore ecological integrity and to keep park ecosystems within threshold conditions. Thresholds are set through consideration of reference ecosystems, standards and guidelines, historical reconstructions, biological patterns, trends, and expert opinion (Woodley 1993; Parks Canada 2005).

Under the guidance of ecological integrity, Canadian park managers do not attempt to eliminate every form of human disturbance. Rather, park managers work to mimic some of the effects of aboriginal populations where ecosystems coevolved with aboriginal management. Moreover, since specific landscapes can support many alternative ecosystem states while retaining ecological integrity, Parks Canada must determine preferred states to provide clear guidance and direction for interventions. Every five years, Parks Canada requires the preparation of state of park reports for each national park, complete with detailed indicators, measures, thresholds, and targets for management. These feed into park management plans, which set an ecological vision and the required management actions for the park (Parks Canada 2005).

Conserving biodiversity is a key feature of ecological integrity. Protected areas that adopt ecological integrity as a goal might maintain native biodiversity, even if community structure and composition is no longer natural. Species distributions and abundances might fall outside the range of historic variability. Management interventions might be ongoing and large in scale to preserve particular ecosystem components.

Resilience

Resilience has also emerged as a concept that is useful when dealing with dramatic but uncertain and unpredictable change. Holling (1973) defines "resilience" as the capacity of a system to absorb change and still persist without undergoing a state shift or fundamental loss of character. Holling and others distinguish ecological (or socioecological) resilience from engineering resilience (the rate at which a perturbed system returns to its initial state), which emphasizes efficiency rather than adaptive capacity. More critically, resilience is a meaningful goal only if one specifies what is to be resilient, and to what it should be resilient. Resilience is a means to an end, so protected area managers must still decide on specific goals and objectives.

The growing literature about resilience conceptualizes social and ecological systems as interlinked (e.g., Folke et al. 2002; Gunderson and Holling 2002; Walker and Salt 2006) arguing for management across scales, with an understanding that protected areas must be managed in the context of larger landscapes and regional social, cultural, political, and ecological systems. According to resilience theory, attempting to prevent or resist change is likely to increase the risk of larger future change—the past should not be preserved if it comes at the cost of reduced resilience. Several broad strategies for promoting resilience, along with specific ways to promote each strategy, have been articulated (Table 2).

Managing protected areas for ecological resilience, rather than naturalness, might emphasize retaining ecosystem function over preserving specific species *in situ*. It might require letting go of the way landscapes look today as conditions change and identifying key processes to retain in the face of change, such that although many other variables shift around, core functions and processes maintain their resilience. Recommended tools for building resilience include experimentation, active adaptive management, and structured scenario planning—"envisioning alternative futures in

Table 2. Strategies for promoting the resilience of desired systems.

Reduce vulnerability by:
- sustaining the slow variables (e.g., soil resources and the species pool)—the reserves in the system that accumulate slowly and provide buffers
- mitigating the stresses that drive change

Enhance adaptability by:
- fostering ecological, economic, and cultural diversity, including diversity in space and diversity in management strategy—protecting the building blocks for change that will maximize future options
- creating capacity for learning and innovation at multiple scales

Enhance resilience by:
- strengthening stabilizing feedbacks, particularly negative feedbacks and tight feedback loops between actions and their consequences
- sustaining ecological and cultural legacies, including cultural connections to the land, thereby retaining system memory
- building linkages across multiple scales, including adaptive governance and connectivity between parks and the surrounding matrix

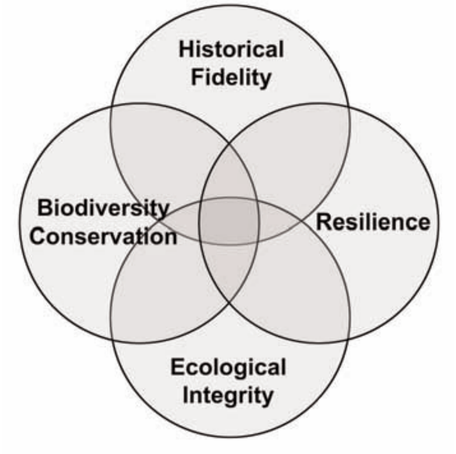
Foster transformability (the ability to actively move to a desired novel system, as an alternative to passive degradation) by:
- thinking outside the box
- treating crisis as an opportunity for constructive change

ways that expose fundamental variables and branch points that may be collectively manipulated to evoke change" (Folke et al. 2002:52).

Adopting a pluralistic and adaptive approach: Complementary but diverse goals and strategies

Although there was concern about some of the meanings of naturalness, there was general support among workshop participants for the notion of historical fidelity—the importance of continuity between future ecosystems and those of the past. The group felt that there was substantial overlap between the concepts of historical fidelity, ecological integrity, and resilience, as well as with the goal of conserving biodiversity. We might look to the nexus of these four concepts for guidance regarding the specifications of desired future conditions for protected area ecosystems (Figure 3). At the nexus, park and wilderness ecosystems would be characterized by a relatively low level of human influence (compared with the developed world), managing with as light a "touch" as possible, substantial similarity to past landscapes (including expertly mimicking aboriginal influence), persistence of most native elements and processes, and a high capacity to adapt to an unpredictable future (through collaborative goal-setting, experimentation and adaptive management, and managing across landscapes). Advocates of the naturalness concept might argue that naturalness implies all four of these elements; so might advocates of the ecological integrity concept.

Figure 3. Historical fidelity, biodiversity conservation, ecological integrity, and resilience fit together.



Despite their overlap, however, each concept also has unique meanings. The value of parks and wildernesses can be optimized by providing for a diversity of management objectives, particularly given uncertainty about the impacts of climate change and other stressors. While a core goal of protected areas is biodiversity conservation, more specific goals might include preserving historic communities and landscapes (vignettes of primitive America, as proposed by Leopold et al. 1963), conserving specific endangered or endemic species, maintaining forest structure and function, allowing ecosystems to respond to change without human intervention (a hands-off approach), sustaining subsistence activities (as in some Alaska protected areas), or enhancing the resilience of a particular grassland. Managing to preserve historic landscapes will likely be more the exception than the rule, since in many cases such efforts are the equivalent of swimming upstream (i.e., maintenance of such landscapes will often require ongoing intervention and investment of resources). At the opposite end of the spectrum, managers may need to anticipate and guide change, to actively transform systems rather than let them passively degrade—to create novel ecosystems in new places, for the purpose of protecting something of value and enhancing system resilience.

A single protected area might adopt different goals in different areas. Protected areas should also employ a diversity of management strategies to achieve a particular goal, since there is substantial uncertainty about the effectiveness of different strategies. However, redundancy is also important; similar strategies should be employed in multiple locations to ensure replicated experiments and buffering. Currently, goals and management strategies are diverse, but for the wrong reasons. Diversity is often the result of personal preference, available resources, lack of coordination, even neglect. It should reflect a large-scale planned and deliberate effort that considers the appropriateness of interventions, scale, boundary effects, and how any particular area fits within a larger system of protected areas and the regional landscape.

Putting pluralism in a landscape context

Although much has already been written about the need to conduct conservation planning at large scales (e.g., Margules and Pressey 2000; Liu and Taylor 2002; Hansen and DeFries 2007), there are few successful examples in park and wilderness stewardship. Even without climate change, our existing parks and wilderness are not large enough to sustain our natural heritage by themselves. Conservation planning must extend beyond the boundaries of protected areas, and climate change makes this scale of planning even more imperative. With climate change, political boundaries are fixed but the biological landscape is not (Lovejoy 2006). When combined with habitat fragmentation, species are less able to migrate to new sites as conditions change, making corridors and connectivity between protected areas and between protected areas and adjacent lands even more important than in the past.

Since a pluralistic approach to protected area conservation requires both diversity and redundancy to maximize future options, protected area managers must work with each other and with other types of landowners to ensure that particular ecosystems are managed in both similar and dissimilar ways. Scale needs to be carefully considered as managers make decisions about conservation strategies and interventions. Planning must occur at multiple scales, so that protected area managers understand how conditions are changing across the landscape and recognize key opportunities.

We must become better at understanding the consequences of localized, short-term change at large spatial and temporal scales (White and Jentsch 2005). Localized changes are likely to occur rapidly. Approaches to managing specific protected ecosystems need to be situated within an overall strategy for protected areas within particular ecoregions. Creating and maintaining connectivity and conserving biodiversity across landscapes is challenging institutionally, politically, and ecologically, but it is absolutely necessary in the context of global change and diverse and novel stressors.

Toward more flexible and adaptive planning

Traditionally, protected area managers have translated goals into operational objectives and specific targets—statements of desired future conditions. The concept of desired future conditions implies an understanding of alternative future states to choose among, the costs and benefits of different alternatives, the resources required to achieve each state, and the likelihood of success. But the specter of climate change suggests a future where change is rapid and directional and the thing we can be most certain about is uncertainty (Saunders et al. 2007). As change and uncertainty increase, managers are less likely to possess the requisite knowledge to specify desired future conditions. Attempts to achieve long-term objectives, as conditions change, could lead to loss of biodiversity, decreased resilience, and ecosystem degradation.

Climate change and other novel stressors call for a very different type of planning model—one built around objectives that are frequently assessed and renegotiated. Goals may be enduring, but objectives may need to be more flexible. The time frame for objectives may need to be shortened. What appear to be realistic future options may prove unrealistic, while new options may appear. Managers will need to be more adaptive, regularly revisiting objectives and management decisions and changing them as knowledge advances and uncertainty retreats (Folke et al. 2002). Managers need the flexibility to respond to deliberate experimentation and effectiveness monitoring.

What can we do now?

The primary conclusion of our workshop was that new attention needs to be given to the purposes and values of parks and wilderness areas. Philosophical issues need to be raised and resolved so that more clarity can be provided regarding the stewardship of ecosystems in parks and wilderness. That is the first order of business. Scientists might contribute to this process by (1) raising questions about naturalness (as we do in this paper) and continuing to explore new definitions and concepts and (2) predicting the likely outcomes of alternative policy goals.

At the workshop, we also spent some time articulating management options for dealing with rapid and unexpected change in protected areas. To some degree, the appropriateness of these strategies can only be evaluated after basic philosophical issues have been resolved. Therefore, these options are listed in an Appendix rather than the main body of our paper.

Summary

The key challenge to stewardship of park and wilderness ecosystems is to decide where, when, and how to intervene in physical and biological processes to conserve what we value in these places. To make such decisions, planners and managers must more clearly articulate park purposes: what is valued and what needs to be sustained. These values likely include biodiversity conservation, ecological integrity, historical fidelity, aesthetics, and nostalgia, as well as ensuring that some of the lands in the United States are managed with restraint and humility, where nature is allowed to take its own course. Where interventions are needed, planners and managers need to more precisely define what outcomes are desired.

The concept of naturalness provides insufficient guidance to make such decisions, as does the admonition to intervene as little as possible. Perhaps it is unfortunate that people are so familiar with the word "natural." This familiarity leads both lay people and scientists to assume they know what it means. But the varied notions of naturalness are often tangled and they have evolved over time. Although there have been efforts to disentangle meanings (e.g., Landres et al. 1998), naturalness continues to mean different things to different people—depending on their knowledge, their experience, and their values. Inconsistent and imprecise definitions ultimately are manifested in poor stewardship.

Although workshop participants disagreed about the desirability of retaining naturalness as the core concept in protected area stewardship, there was general agreement that the concept has both desirable and undesirable implications. Some of the valued notions implicit within the concept of naturalness are intervening as little as possible, valuing past landscapes and systems, and avoiding human dominance of ecosystems. Notions to reject include attempting to make landscapes of the future replicates of the past and not acknowledging the major effects that humans have had on park landscapes for millennia and will have in the future. Beyond naturalness, park and wilderness stewardship needs to be guided by concepts such as ecological integrity and resilience.

Given the unprecedented rate of change that we face, it is time for a re-examination of the goals and purposes of parks and wilderness areas. What seems possible now is very different from what seemed possible 50 or 100 years ago. Priorities have changed as well. What attributes of these places are we most concerned about protecting—or most concerned about losing—in the face of rapid change? Beyond new guidance and policy, there is also a need for institutional change. For ecosystems to be resilient, institutions need to be resilient. In particular, planning processes will need to be more adaptive and more learning-focused, and be capable of operating at large spatial scales and across diverse land ownerships.

Appendix: Recommended strategies and things to consider in responding to rapid and unexpected change

This is a toolbox of options to be used on a case-by-case basis, not as a one-size-fits-all prescription.

Planning and prioritizing

- Work to clearly define the goals and objectives for each protected area. In some cases, current goals may need to be redefined (e.g., from "maintain giant sequoias at this site" to "maintain soil, forest cover, and species diversity"). Goals will need to be revisited as conditions change and knowledge evolves.
- Prioritize current and future threats and changes. Focus on actions that have the most potential to make a difference. Practice triage when necessary.
- Decide which changes are acceptable and to what degree they are acceptable (e.g., some invasive species, like cheatgrass, are impossible to control in large areas).
- Define undesired future conditions. Determine what to avoid (e.g., extinctions, sudden loss of vegetation and soil).
- Be prepared for surprises, as change might not always be directional and may occur in spurts.
- Carefully consider the philosophical and practical implications of proposed interven-

tions. If possible, base decisions on established criteria and thresholds, as well as a plan for implementing different levels of intervention in different places.

- Consider the appropriate scale for management actions. In some cases, starting at a small scale might be desirable. However, in others—where the threat is widespread, the effectiveness of the intervention has been established, and the resources are available—consider larger-scale interventions.
- Implement different strategies in different sections of each protected area (provide buffering in case one or more strategies fail). At the same time, pursue redundancy (implement similar approaches in several areas).
- Experiment to determine the effects of different management actions. Where possible, try out management interventions at small scales and more than one site, then monitor interventions along with control (untreated) areas to maximize learning. Experiment with new tools at an appropriate scale (small pilot projects) before utilizing in large areas.
- Be cautious about models that predict the responses of particular communities to changing conditions. Biological models are much less certain than climate models, which still cannot determine the precise amount of temperature change or future precipitation. Seek information about the responses of particular species, but view the information as general guidance rather than specific predictions. Use models to explore a range of scenarios in planning processes, not to predict specific future conditions.
- Monitor for change and early detection of changes to populations and ranges. Monitor to understand the effects of management actions. Monitor smart, not hard; simple information collected consistently and with a plan is more valuable than complex, detailed data collection with no particular strategy for learning from it.
- Of particular importance, determine how you will know when a system is undergoing a state change to which resistance is futile. So far as possible, know beforehand whether you will passively accept the change or actively assist in transformation to a new system.
- Plan at multiple temporal and spatial scales. Identify short-term and long-term goals and actions. Manage both short-term processes (such as disturbance events) and long-term processes (such as the accumulation of soil fertility). Consider individual protected areas within a larger landscape context.
- Inform the public of the impacts of climate change, pollution, and other stressors on protected areas. Ensure that policy-makers understand the implications of climate change and other environmental changes on protected areas.
- Promote policies that encourage connectivity and conservation across the larger landscape. Develop incentives for private landowners to provide habitat for migrating species.
- Maintain and enhance a variety of human relationships with protected areas. Cultural, social, and material connections with protected areas will ensure that the public understands, supports, and participates in management actions.
- Consider socially important and symbolic species and landscapes in planning. Values such as wildness, nostalgia, and humility will influence the public debate about protected area conservation.

- Engage the public in the planning process in a meaningful and ongoing manner. Collaborative approaches that emphasize dialogue can build public support for management actions and policy change.
- Conduct scenario planning (with public involvement). Consider multiple possible futures and multiple possible outcomes for proposed management actions. Develop portraits that detail desirable and undesirable futures for protected area ecosystems. Use these portraits to determine which management actions are most likely to lead to desired future options.

Mitigation and conservation

- Restore disturbance regimes, such as fire and flooding, where they favor native species and maintain important ecological processes. Consider using disturbance to reset ecosystem trajectories. For example, after a wind event consider replanting species better adapted to warmer temperatures.
- Restore extirpated species (consider whether the species are likely to survive at that site in the future or will be able to migrate to new sites).
- Prevent and mitigate threats, such as non-native invasive species, using a variety of tools. Often, prevention greatly reduces the need for later, more costly interventions, as when exotic species are prohibited from establishing in a protected area rather than having to be controlled or extirpated after they have been established.
- Sustain "slow variables," such as soil characteristics and regional species pools, that may require managers to consider longer time scales and larger spatial scales, to maintain ecosystem capacity to recover on its own from shocks and to boost adaptive capacity.
- Conserve dominant and seemingly minor species. Species or plant communities that are not currently abundant, such as pockets of desert vegetation in California grasslands, may become more important as conditions change.
- Create conditions resistant and resilient to climate change and other stressors. For example, consider overthinning some forests, seeding restoration sites with a wider range of species or ecotypes, or seeding with native species known to resist problem invaders. Resistance implies the ability to stay the same despite changing conditions; remain alert to the distinction between the need for resisting versus adapting to change.
- Consider and, if necessary, prepare for assisted migration of species in response to climate change.
- Although controversial, consider functional substitutes for species that cannot survive under current conditions. Consider realigning systems to current conditions, especially where the system is already well beyond the range of natural variability. And consider active transformation to a new system if building resilience of the current system to change seems impossible. Weigh the possibility that passive degradation will occur if active transformation is not pursued.

References

Angermeier, P.L. and J.R. Karr. 1994. Biological integrity versus biological diversity as policy directives. *BioScience* 44, 690–697.

Christensen, N.L., Jr. 1988. Succession and natural disturbance: Paradigms, problems, and preservation of natural ecosystems. In *Ecosystem Management for Parks and Wilderness*. J. K. Agee and D. R. Johnson, eds. Seattle: University of Washington Press, 62–86.

Cole, D.N. 2000. Paradox of the primeval: Ecological restoration in wilderness. *Ecological Restoration* 18, 77–86.

Cole, D.N., and P.B. Landres. 1996. Threats to wilderness ecosystems: Impacts and research needs. *Ecological Applications* 6, 168–184.

Cole, K.L., K. Ironside, P. Duffy, and S. Arundel. 2005. Transient dynamics of vegetation response to past and future climatic changes in the southwestern United States (poster). Online at www.climatescience.gov/workshop2005/posters/P-EC4.2_Cole.pdf.

Folke, C., et al. 2002. Resilience and sustainable development: Building adaptive management in a world of transformation. Series on Science for Sustainable Development no. 3, International Council for Science.

Fox, D. 2007. Back to the no-analog future. *Science* 316, 823–825.

Franklin, J.F., and G.H. Aplet. 2002. Wilderness ecosystems. In *Wilderness Management: Stewardship and Protection of Resources and Values*. J.C. Hendee and C.P. Dawson, eds.. Golden, Colo.: Fulcrum, 263–285.

Frey, D. 1975. Biological integrity of water: An historical perspective. In *The Integrity of Water.* R.K. Ballentine and L.J. Guarraia, eds. Washington, D.C.: Environmental Protection Agency, 127–139.

Gillson, L., and K.J. Willis. 2004. 'As Earth's testimonies tell': Wilderness conservation in a changing world. *Ecology Letters* 7, 990–998.

Graber, D.M. 1983. Rationalizing management of natural areas in national parks. *The George Wright Forum* 3, 48–56.

Gunderson, L.H., and C.S. Holling, eds. 2002. *Panarchy: Understanding Transformations in Human and Natural Systems.* Washington, D.C.: Island Press.

Hansen, A.J. and R. DeFries. 2007. Ecological mechanisms linking protected areas to surrounding lands. *Ecological Applications* 17, 974–988.

Harris, J.A., R.J. Hobbs, E. Higgs, and J. Aronson. 2006. Ecological restoration and global climate change. *Restoration Ecology* 14, 170–176.

Higgs, E. 2003. *Nature by Design: People, Natural Process, and Ecological Restoration*. Cambridge, Mass.: The MIT Press.

Holling, C.S. 1973. Resilience and stability of ecological systems. *Annual Review of Ecology and Systematics* 4, 1–24.

Karr, J.R., and D.R. Dudley. 1981. Ecological perspective on water quality goals. *Environmental Management* 5, 55–68.

Kay, J.J. 1993. On the nature of ecological integrity: Some closing comments. In *Ecosystem Integrity and Management of Ecosystems.* S.J. Woodley, G. Francis, and J. Kay, eds. Del Ray Beach, Fla.: St. Lucie Press, 201–212.

Kay, C.E. 1995. Aboriginal overkill and native burning: Implications for modern ecosystem management. *Western Journal of Applied Forestry* 10, 121–126.

Landres, P.B., P. Morgan, and F.J. Swanson. 1999. Overview of the use of natural variability concepts in managing ecological systems. *Ecological Applications* 9, 1179–1188.

Landres, P.B., P.S. White, G. Aplet, and A. Zimmermann. 1998. Naturalness and natural variability: Definitions, concepts and strategies for wilderness management. In *Wilderness and Natural Areas in Eastern North America.* D.L. Kulhavy and M.H. Legg, eds. Nacogdoches, Tex.: Center for Applied Studies in Forestry, Stephen F. Austin State University, 41–52.

Leopold, A.S., S.A. Cain, D.M. Cottam, I.N. Gabrielson, and T.L. Kimball. 1963. Wildlife management in the national parks. *Transactions of the North American Wildlife and Natural Resources Conference* 28, 28–45.

Liu, J., and W. Taylor, eds. 2002. *Integrating Landscape Ecology into Natural Resource Management.* Cambridge, U.K.: Cambridge University Press.

Lovejoy, T.E. 2006. Protected areas: A prism for a changing world. *Trends in Ecology and Evolution* 21, 329–333.

Mann, C.C. 2005. *1491: New Revelations of the Americas Before Columbus*. New York: Knopf.

Margules, C.R., and R.L. Pressey. 2000. Systematic conservation planning. *Nature* 405, 243–253.

Millar, C.I., and L.B. Brubaker. 2006. Climate change and paleoecology: New contexts for restoration ecology. In *Foundations of Restoration Ecology: The Science and Practice of Ecological Restoration.* D. Falk , M. Palmer and J. Zedler, eds. Washington, D.C.: Island Press, 315–340.

National Park Service. 2006. *Management Policies 2006*. Washington, D.C.: National Park Service.

Parks Canada Agency. 2005. *Monitoring and Reporting Ecological Integrity in Canada's National Parks. Volume I: Guiding Principles.* Ottawa: Parks Canada Agency.

Pyne, S.J. 1997. *Fire in America*. Seattle: University of Washington Press.

Rolston, Holmes, III. 2001. Natural and unnatural; wild and cultural. *Western North American Naturalist* 6, 267-276.

Ridder, B. 2007. The naturalness versus wildness debate: Ambiguity, inconsistency, and unattainable objectivity. *Restoration Ecology* 15, 8–12.

Saunders, S., T. Easley, J.A. Logan, and T. Spencer. 2007. Losing ground: Western national parks endangered by climate disruption. *The George Wright Forum* 24:1, 41–81.

Sellars, R.W. 1997. *Preserving Nature in the National Parks: A History.* New Haven, Conn.: Yale University Press.

SERI [Society for Ecological Restoration International] Science & Policy Working Group. 2006. *The SER International Primer on Ecological Restoration.* Tucson, Ariz.: Society for Ecological Restoration International.

Stephenson, N.L. 2005. Wilderness management in an era of rapid global changes: The death of "natural" and redefinition of goals. Unpublished abstract from the World Wilderness Congress, Anchorage, Alaska.

Sydoriak, C.A., C.D. Allen, and B.F. Jacobs. 2001. Would ecological landscape restoration make Bandelier Wilderness more or less of a wilderness? *Wild Earth* 10:4, 83–90.

Vale, T.R. 2002. The pre-European landscape of the United States: Pristine or humanized? In *Fire, Native Peoples, and the Natural Landscape.* T.R. Vale, ed. Washington, D.C.:

Island Press, 1–39.

Walker, B., and D. Salt. 2006. *Resilience Thinking: Sustaining Ecosystems and People in a Changing World.* Washington, D.C.: Island Press.

White, P.S., and S.P. Bratton. 1980. After preservation: Philosophical and practical problems of change. *Biological Conservation* 18, 241–255.

White, P.S., and A. Jentsch. 2005. Developing multipatch environmental ethics: The paradigm of flux and the challenge of a patch dynamic world. *Silva Carelica* 49, 93–106.

Willis, K.J., and H.J.B. Birks. 2006. What is natural? The need for a long-term perspective in biodiversity conservation. *Science* 314, 1261–1265.

Woodley, S. 1993. Monitoring for ecological integrity in Canadian national parks. In *Ecosystem Integrity and Management of Ecosystems.* S.J. Woodley, G. Francis, and J. Kay, eds. Del Ray Beach, Fla.: St. Lucie Press, 155–176.

Wu, J., and O. Loucks. 1995. From balance of nature to hierarchical patch dynamics: A paradigm shift in ecology. *Quarterly Review of Biology* 70, 439–466.

David N. Cole, Aldo Leopold Wilderness Research Institute, 790 East Beckwith, Missoula, Montana 59801; dcole@fs.fed.us

Laurie Yung, Wilderness Institute, College of Forestry and Conservation, University of Montana, Missoula, Montana 59812; laurie.yung@umontana.edu

Erika S. Zavaleta, Environmental Studies Department, University of California, Santa Cruz, California 95064; zavaleta@ucsc.edu

Greg H. Aplet, The Wilderness Society, 1660 Wynkoop Street, Suite 850, Denver, Colorado 80202; greg_aplet@tws.org

F. Stuart Chapin III, Department of Biology and Wildlife, University of Alaska, Fairbanks, Alaska 99775; terry.chapin@uaf.edu

David M. Graber, Sequoia and Kings Canyon National Parks, 47050 Generals Highway, Three Rivers, California 93271-9651; david_graber@nps.gov

Eric S. Higgs, School of Environmental Studies, University of Victoria, Victoria, British Columbia V8W 2Y2 Canada; ehiggs@uvic.ca

Richard J. Hobbs, School of Environmental Science, Murdoch University, Murdoch, Western Australia 6150 Australia; R.Hobbs@murdoch.edu.au

Peter B. Landres, Aldo Leopold Wilderness Research Institute, 790 East Beckwith, Missoula, Montana 59801; plandres@fs.fed.us

Connie I. Millar, Pacific Southwest Research Station, U.S. Department of Agriculture–Forest Service, P.O. Box 245, Berkeley, California 94701-0245; cmillar@fs.fed.us

David J. Parsons, Aldo Leopold Wilderness Research Institute, 790 East Beckwith, Missoula, Montana 59801; djparsons@fs.fed.us

John M. Randall, The Nature Conservancy and Department of Vegetable Crops & Weed Science, University of California, Davis, California 95616; jarandall@ucdavis.edu

Nathan L. Stephenson, U.S. Geological Survey Western Ecological Research Center, 47050 Generals Highway. Unit 4, Three Rivers, California 93271-9651; nstephenson@usgs.gov

Kathy A. Tonnessen, Rocky Mountains Cooperative Ecosystem Studies Unit, College of Forestry and Conservation, University of Montana, Missoula, Montana 59812; kathy.-tonnessen@cfc.umt.edu

Peter S. White, Department of Biology, University of North Carolina, Chapel Hill, North Carolina 27599-3280; peter.white@unc.edu

Stephen Woodley, Ecosystem Science, Parks Canada, 25 Eddy Street, Gatineau, Quebec K1A 0M5 Canada; stephen.woodley@pc.gc.ca