Climate change: Wilderness's greatest challenge

By Nathan L. Stephenson and Constance I. Millar

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

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

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

Abstract

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

Key words

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

The Wilderness Act in the era of rapid climatic changes

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

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

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

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

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

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

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

Classes of actions to consider

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

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

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

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

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

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

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

Planning considerations

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

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

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

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

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

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

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

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

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

Conclusion

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

Acknowledgments

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

Literature cited

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

About the authors

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

PS