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Wilderness Preserves: Still Relevant and Resilient After All These Years

Sandra Zellmer
University of Nebraska College of Law, szellmer2@unl.edu

John M. Anderies
Arizona State University, marty.anderies@asu.edu

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Sandra Zellmer and John M. Anderies
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I. Introduction

Since the late nineteenth century, policymakers and conservation groups in the United States have devoted a great deal of attention to preserving natural places. (Hays 1959) Wilderness preserves, in particular, represent both the legacy of America's past—remnant patches of the vast lands occupied for millennia by Native Americans and by wild creatures—and our options and hopes for a biologically and culturally resilient future. (Scott 2004) Wilderness areas provide many ecological and anthropocentric benefits, including habitat for a diverse array of species, watershed protection, carbon sequestration, recreational opportunities, beauty, and quiet sanctuary. In describing one "lovely and terrible," "harshly and beautifully colored" wild area in Utah, author Wallace Stegner explained, "We simply need that wild country . . . [f]or it can be a means of reassuring ourselves of our sanity as creatures, a part of the geography of hope." (Stegner 1960)

Stegner wrote those lines a half-century ago. Although the strategy of setting aside certain wild or natural areas has served the nation well in the past, it is not clear that it will prove to be a viable conservation strategy in the future. Scientists have sounded the alarm: rapid and dramatic changes in climate are threatening the ability of ecological communities and processes to persist. (IPCC 2007) Adaptation strategies that promote resilient local and regional ecosystem responses to climate change will be imperative. In some areas, such strategies may include active intervention to foster transitions to more resilient ecological communities. (Galatowitsch 2009) For wilderness preserves, the desire for adaptation strategies raises a compelling question: Does it still make sense to protect wilderness areas from human intrusion?

This chapter explores the continuing relevance of preserving wilderness by preventing active human intervention. It concludes that the symbolic and ecological benefits of wilderness are as significant today as they were fifty years ago. Indeed, the importance of preserving wilderness areas will only increase as the climate changes. Land managers face complex challenges, however, when they are managing wilderness resources that are already degraded due to climate change or other human impacts and that may require intervention to prevent further degradation. Deciding whether and how to intervene with active management tools while maintaining the overarching "wild" values of wilderness is a difficult but perhaps not impossible task. It's a fair bet, though, that historic characteristics and variability can no longer be the primary reference points for decisionmaking, and that strategic approaches to monitoring and managing existing, expanded, and new preserves will be necessary. (Craig 2010)

We propose three threshold inquiries to be answered in the affirmative before a wilderness restoration project is undertaken. First, is there sufficient understanding about reference conditions and processes, as well as the long term effects of restoration actions? Second, is restoration even possible in a particular wilderness area, given the pervasiveness of ecological change? Finally, can humans extricate themselves within some discrete period of time and let the ecological processes indicative of pre-degraded characteristics resume functioning? If the answer to all of these questions is yes, then it may be acceptable to prioritize the need of the natural system for active restoration-oriented interventions over society's need to keep wilderness areas wild and untrammeled.

II. Naturalness and Wilderness

The Wilderness Act of 1964 is widely known as one of the nation's preeminent preservation statutes. (Rodgers 1994) Today, federally designated wilderness areas are found within each major category of federal lands—National Forests, National Parks, Wildlife Refuges, and public lands managed by the Bureau of Land Management. There are nearly 700 federally designated wilderness areas in 44 states, covering 109 million acres of land or around five percent of the U.S. land base. (Gorte 2008) About 75 percent of the wilderness in the lower 48 states is located within only five ecoregions—one desert ecoregion, the Mojave Desert of California, and four high elevation ecoregions: the Rocky Mountains, California's Sierra Nevada Mountains, and the Cascade Mountains of the Pacific Northwest. (Wilderness Society 2011)

Over the years, the Wilderness Act has been remarkably stable and robust, with few legislative revisions to its substantive requirements. The Act is so well loved that, as Professor Bill Rodgers notes, it is "virtually repeal-proof." (Rodgers 1994) During almost every congressional session since 1964, new wilderness areas have been added to the system or existing areas have been expanded. Once established, Congress rarely de-designates wilderness areas, although it occasionally authorizes land exchanges that release land from wilderness study. (Scott 2004).

The Wilderness Act directs that a wilderness area must be "protected and managed so as to preserve its *natural conditions*." (Wilderness Act § 1131(c)) Neither "natural" nor "wild" is specifically defined in the Act. "Natural" is commonly understood as "produced or existing in nature," as opposed to artificial or human-made. (Merriam-Webster's Collegiate Dictionary 2003.) In ordinary parlance, "wild" means free, untamed, autonomous, and "in a state of nature." (*Id.*) The principal author of the Wilderness Act, Howard Zahniser, defined the term "wild" as "untrammeled": *"not subject to human controls and manipulations that hamper the free play of natural forces."* (Zahniser 1959) The Act specifies that only those lands retaining a "primeval character and influence," which are "affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable," qualify as wilderness. (Wilderness Act § 1131(c))

Because federal wilderness areas are to remain both natural and free of human manipulation, wilderness designations impose the most restrictive management directives in federal law, far more so than the directives that apply to National Parks, National Forests, Wildlife Refuges, and other federal land categories. (Wilderness Society 2003) In fact, when surveyed about their ability to implement climate adaptation policies, federal land managers indicated that the constraints imposed by the Wilderness Act could act as a potential barrier. (Jantarasami 2010)

While the congressional mission for the National Park System provides the closest analogy to the Wilderness Act's mission, even the national parks (non-wilderness areas of parks, that is) are managed quite differently than wilderness areas. The National Park Service Organic Act of 1916 provides that "the fundamental purpose" of parks is two-fold: "to conserve the scenery and the natural and historic objects and the wild life therein *and* to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations." (National Park Service Organic Act 1916) (emphasis added) Congress began setting aside federal public lands as national parks for conservation and recreational purposes in 1872 with the establishment of Yellowstone National Park. (Act of Mar. 1, 1872) There is an elemental distinction between parks like Yellowstone and wilderness areas, however; there can be no permanent roads in wilderness areas, and motorized or mechanized means of transportation are generally prohibited in wilderness areas but are quite common—even prevalent—in national parks. The absence of roads and motors is the hallmark of wilderness, distinguishing wilderness areas from all other categories of federal as well as state and private land.

To ensure that natural conditions and wild characteristics are preserved, the Wilderness Act imposes a variety of management restrictions. Specifically, as noted above, the Act prohibits most roads, and it also forbids motor vehicles, motorized equipment, mechanical transport, aircraft landings, and structures or installations, "except as necessary to meet minimum requirements for the administration of the area." (Wilderness Act § 1133(c)) Does this mean that land managers must stand back while wilderness areas "evolve in whatever direction Nature chooses (be free-willed) . . . regardless of pre-existing condition or future consequences"? (Sydoriak 2000) Not necessarily. As the Ninth Circuit Court of Appeals observed, "Congress did not mandate that the Service preserve the wilderness in a museum diorama, one that we might observe only from a safe distance, behind a brass railing and a thick glass window."

(Wilderness Watch 2010) Rather, wilderness is to be "made accessible to people, 'devoted to the public purposes of recreational, scenic, scientific, educational, conservation, and historical use.'" (*Id.;* Wilderness Act § 1133(b)) In addition to limited use of motorized or mechanical measures "as necessary to meet minimum requirements for the administration of the area," the Act also authorizes "such measures . . . as may be necessary in the control of fire, insects, and diseases, subject to such conditions as the Secretary deems desirable." (Wilderness Act § 1133(d)(1))

III. Climate Threats to Naturalness and Wildness

In the mid-twentieth century, when the Wilderness Act was passed, preventing active manipulation of land and natural resources within this one special category of federal lands made good sense. The human population was growing, and Americans were becoming more affluent and had more free time and the means to travel to remote areas and to recreate with all sorts of mechanical or motorized devices. Meanwhile, industrialization—large-scale mining and pollution from a wide range of activities—was becoming more widespread and, in many cases, more destructive. In 1964 and in the next few decades, creating and maintaining a system of untrammeled, natural preserves seemed attractive and even critical. In the twenty-first century, however, the changes wrought by climate change are making some question whether maintaining wilderness areas will be possible in the future, and whether devoting resources to such an effort makes any sense. (Galatowitsch 2009; Camacho 2011) Moreover, even if the effort is made, its not at all clear that it will be possible to keep something both wild—untrammeled and unmanipulated—and natural—exhibiting only those processes and functions that would be found in nature absent human influence. (Cole 2001)

For some if not most areas, a dramatically warming climate creates a "no analog" future. (Williams 2007; Ruhl 2008) Although land managers might look to existing ecological conditions, processes, and functions in southern or low elevation areas to predict future conditions, processes, and functions in northern or high elevation areas and to plan future scenarios and management responses (Galatowitsch 2009), bringing climate models down to the fine-scale level needed to make timely on-the-ground management decisions may seem little better than reading tea leaves. Precipitation patterns, vegetative shifts, species migration and invasions, wind, and soil composition are likely to change in unpredictable ways.

Temperature increases in the American West—where most wilderness areas exist—are likely to be even greater than the projected 3° to 10°F worldwide increase by the end of the century. (Saunders 2005) Storms, floods, drought, fire, disease, insect infestation, and species invasions are likely to become more severe and widespread. Some scientists believe that the effects will be most intense at higher elevations, including alpine and sub-alpine wilderness areas. As a result, the natural ecological characteristics that set an area apart and qualified it for wilderness designation will almost certainly change over time as glaciers melt and precipitation patterns change. Examples include the following:

Diminished snowpack and earlier snowmelt. More winter precipitation will fall as rain instead of snow, periods of snowpack accumulation will be shorter, and earlier springtime warming will melt snowpacks earlier in the year. Peak flows will occur sooner than the current situation of early to mid-summertime peak flows, and this may cause severe flooding and soil erosion downstream in the spring as well as diminished water supplies later in the year. (Saunders 2005; U.S. Global Change Research Program 2003)

Increased evaporation, erosion, and dust. Higher temperatures will cause greater evaporation from reservoirs, lakes, and streams, and will also cause soil dryness, loss of vegetation, and erosion. More dust and other airborne particulate matter will result in more air pollution and reduced visibility. (Munson 2011)

Fire. A warmer climate will lead to more frequent and more severe fires and a longer fire season in the West. Scientists with the U.S. Forest Service Climate Change Resource Center believe that relatively modest changes in mean climate will lead to substantial increases in area burned. For a mean temperature increase of 4°F, annual area burned by wildfire is expected to increase by as much as five-fold. Ponderosa pine forests at mid- to high elevations are already facing much harsher fire regimes due to fire suppression and drought. Crown fires in these forests will cause extensive tree mortality, severe soil erosion, and nutrient losses. (McKenzie 2004)

Disease and infestation. Plant diseases and insect infestations are strongly influenced by weather and climate. Heat and drought can stress and overwhelm the physiological capability and structural integrity of plants. Climate change, coupled with invasive species and fire suppression, creates conditions conducive for devastating forest diseases and infestations. (Neilson 2008)

Shifting ranges and extinctions. Scientists have already begun to observe shifts in the ranges of plant and animal species in the last century. Some species have climbed upward in elevation or migrated toward the North or South Pole as they seek areas within their temperature tolerances. New species have colonized cooler regions, including sea anemones in Monterey Bay and lichens and butterflies in northern Europe. Based on studies of over 1,700 species, Parmesan and Yohe found "highly significant, nonrandom patterns of change in accord with observed climate warming in the twentieth century, indicating a very high confidence (.95%) in a global climate change fingerprint." (Parmesan and Yohe 2003) But some species, such as the Arctic fox, are occupying a smaller range—they have nowhere cooler to go. (Parmesan 2005) In a 2004 paper in *Nature,* scientists concluded that climate change could shrink the ranges of 15 to 37 percent of all species so drastically that they would be "committed to extinction." (Thomas 2004) It is not possible to place the blame solely on climate change because other variables like habitat destruction due to development also play a role, but it seems more likely than not that a warming climate is a substantial factor in these rapid changes. (Ruhl 2008)

IV. Human Threats to Naturalness and Wilderness

Climate change is not only changing the composition of existing wilderness preserves, but it may also increase human pressure to intervene and alter ongoing processes in hopes of mitigating adverse effects or adapting to them. For example, there may be more pressure to log forests to contain fire, disease, and infestation, to eradicate invasive species with mechanical or chemical treatments, to provide artificial water supplies to imperiled species, to reintroduce native species into historic ranges that they no longer occupy, and to translocate non-native imperiled species to cooler, higher elevations in wilderness areas. (Landres 2010) Some of these activities are under consideration and, in some regions, are already underway.

> *Logging and other vegetation management.* Wilderness managers and owners or managers of adjacent lands may push for more logging or other measures to "fire proof" forests and to inhibit the spread of disease and insect infestation. Other proposed strategies to combat disease and infestation include planting disease resistant trees (hybridized or genetically modified), using pesticides and fungicides, and introducing nonnative insect predators. (Cole and Yung 2010)
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> *Artificial water deliveries.* As precipitation patterns change and droughts become more frequent and persistent, wilderness managers may resort to artificial delivery systems to provide water to imperiled species. When bighorn sheep populations began to decline in the Kofa National Wildlife Refuge and Wilderness of southwest Arizona, the U.S. Fish and Wildlife Service (FWS) built a number of water tanks, or guzzlers, within the wilderness area. FWS personnel, in partnership with the Arizona Game and Fish Department, maintain and monitor the tanks. Comprised mostly of aerated PVC pipe buried underground and designed to catch rainwater and channel it into concrete weirs or troughs, each system is capable of holding approximately 13,000 gallons of water. During droughts, refuge personnel transport water to the structures using motorized vehicles and equipment. (Wilderness Watch 2010)
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> *Eradicating invasive species.* Land management agencies sometimes engage in eradication programs in wilderness areas involving shooting, trapping, poisoning, burning, and other measures. Non-native fish species have been a recurring target for rotenone applications in wilderness streams and lakes, and these types of efforts are likely to increase as managers attempt to mitigate or adapt to the effects of climate change. (U.S. Dept. of Agriculture Forest Service 2010; U.S. Dept. of Interior 2010))

Reintroducing native species. Reintroductions of species that historically occupied wilderness areas but that no longer persist in those areas have already occurred and may be expected to continue. Examples include aerial stocking of cutthroat trout in wilderness lakes and streams cleared of other species through the use of rotenone. One of the most controversial reintroductions involves the Rocky Mountain gray wolf, which had been nearly extirpated throughout the Rockies by human depradation in the early twentieth century. Pursuant to an Endangered Species Act recovery plan, wolves were captured from viable populations in Canada and released into the Greater Yellowstone Ecosystem in the mid-1990s. Recently, a federal court in Idaho approved the use of intrusive monitoring techniques—helicopters—to inventory and track reintroduced wolves and their offspring in wilderness areas. (Wolf Recovery Fnd. 2010)

Assisted migration. Climate-sensitive species may be subject to assisted migration or translocation proposals. Potential climate refugees include the American pika, bighorn sheep, eastern red wolves, San Bernardino flying squirrels, white-tailed ptarmigans, coldwater trout and other fish species, arroyo toads, checkerspot butterflies, and white bark pine. Pika, for example, have historically resided at 5,700 feet elevation, but in recent decades they have crept uphill an additional 2,000 feet. In California and Nevada, they are running out of room to climb. The high peaks and cooler temperatures of wilderness areas in the northern Rockies of Colorado, Wyoming, Montana, and Canada may seem like an attractive new home, but the pika will need help getting there.

V. Conservation Implications, Resilience and Adaptive Management

Given the rapid changes occurring on the landscape, land managers and scholars alike have debated whether the idea of wilderness is an "anachronism" doomed to extinction. (Landres 2008) Even in the 1960s, when the Wilderness Act was passed, wilderness designations were subject to criticism for "locking up" federal lands and making them off-limits to all but low-impact recreational uses. Other critics have focused on the lack of continuing ecological relevance. It is true that most wilderness areas were chosen for reasons other than their biological amenities. Unlike the National Wildlife Refuge System and some other types of preserves, the wilderness system was not designed to ensure that areas with the most biodiversity potential are included within the system; rather, Congress was more concerned with recreational and aesthetic virtues. (Foreman 1998; Callicott 1998) "Consequently, the wilderness system generally protects scenic areas of 'rock and ice' rather than wetlands, grasslands, and other more biologically productive but less visually spectacular areas." (Zellmer 2004) Arguably, the failure to prioritize scientific criteria in designating wilderness areas has resulted in an "artificial human construct" that provides "a cursory snapshot of wild lands frozen in time." (Zellmer 2004) This circa-1960 mindset plays out in the management directives expressed in the Act, which assume that a preserved ecosystem will remain in a desired, steady-state condition. We have since learned that disturbance and change is not only inevitable it is also elemental in maintaining ecological integrity. What, then, can a system of wilderness preserves do in terms of promoting biological diversity and ecological resilience? More to the point, should Congress revise the Wilderness Act to enable managers to employ active adaptive management to promote resilience rather than wild or natural, albeit historic, characteristics?

Scientists have begun to emphasize resilience—the capacity of an ecosystem to tolerate and adapt to disturbances without collapsing into a qualitatively different state—as a replacement for our present stationarity-based approaches that assume that natural systems fluctuate in a predictable way and that strive to keep ecosystems within the historic range of variability. (Holling 1973; Folke 2004) As a conservation strategy, resilience has gained some ground in Congress in recent years. The 2009 Waxman-Markey climate bill passed by the U.S. House of Representatives is a lead example. The bill highlights resilience as a key concept for managing natural resources. It defines resilience as the "ability to resist or recover from disturbance [in order to] preserve diversity, productivity, and sustainability." (H.R. 2454) Although this bill has not been passed, it indicates that Congress is increasingly aware of the need for new conservation approaches.

In recognition of the complexity of ecosystem interactions, resilience theory emphasizes adaptation, flexibility, change, and transformation—concepts that seem antithetical to conservation strategies that insist on the ironclad preservation of areas perceived to be "wild" or "natural." It is not clear that the ecological and social values of wilderness can continue to be met if a greater degree of interactive management is proscribed.

On the scientific side of the ledger, wilderness matters, and the scientific values of many protected wilderness areas will remain intact despite climate change. According to scientists in the U.S. Forest Service—an agency that was once the most outspoken opponent of official wilderness designations—wilderness areas will play an even more critical role in the future. First, wilderness areas provide "baseline" places where ecological lessons can be learned and used to test more intensive adaptation strategies implemented in other areas. In addition, wilderness and other protected areas will continue to provide key ecosystem services such as clean air and water. Roadless areas like wildernesses will also provide undisturbed migration corridors and large blocks of contiguous habitat for climate-threatened species. High altitude wilderness areas also provide elevation gradients in landscapes that have become increasingly fragmented by roads and other development. Increasing connectivity by designing and protecting wildlife corridors and reducing human made barriers such as roads and fences and increasing the number of reserves, especially large protected areas connected by smaller reserves, are among the top climate change adaptation priorities recommended in the scientific literature. (Heller 2009)

Moreover, our current track record for "ecosystem engineering" has been less than stellar. Even when decisionmakers have had the best of intentions and generous funding, their efforts to restore natural features and functions that were degraded or destroyed by development have been spotty. There have been at least as many missteps as successes in the Florida Everglades, the Missouri River, and the late successional reserves and key watersheds of the Pacific Northwest forests. (Zellmer 2009) When it comes to translocating species into novel habitats through assisted migration efforts, ecosystem engineering is even trickier and even less likely to succeed.

Selecting or designing new habitats that will be viable for communities of animal and plant species that have never lived together before and that have incredibly complex life-cycle needs would seem to require god-like knowledge and foresight. Our record for ensuring that intentionally translocated species do not themselves become invasive nuisance species is at least as poor as our ecological restoration track record. (Pimental 2000) Dramatic changes in climate will make our predictive challenges even greater. Active management interventions that upset natural functions and processes in wilderness areas might turn out to be catastrophic.

The social values of wilderness weigh against human-generated manipulations as well. The unique spiritual and symbolic attributes of leaving a few places on earth wild and untouched are unparalleled. No other type of federal, state, or private land can provide the renewal, solitude, and peace found in an area of roadless, non-motorized wilderness. These values are becoming ever more important as we become ever more technologically-driven and connected to cellular towers and satellites and therefore less reflective and less humble in our everyday lives. (Nagle 2005) As Howard Zahniser famously said, we should be guardians of wilderness, not gardeners. (Zahniser 1963) A federal judge carried Zahniser's analogy forward into caselaw: "Nature may not always be as beautiful as a garden but producing gardens is not the aim of the Wilderness Act." (Minnesota Public Interest Research Group 1975)

That said, there may be limited instances when managers should actively intervene to protect or restore unique, irreplaceable wilderness characteristics that have been degraded by human activities. The challenge lies in determining *when* such an instance exists. There are at least three threshold inquiries to be answered in the affirmative before a wilderness restoration project is undertaken. First, is there sufficient understanding about reference conditions and processes, as well as the long term effects of restoration actions? Second, is restoration even possible in a particular wilderness area, given the pervasiveness of ecological change? In other words, will intervention more likely than not improve the functioning and integrity of the ecosystem, including its biological, chemical, and geophysical characteristics? (Landres 2004) Third, can humans extricate themselves within some discrete period of time and let the ecological processes indicative of the pre-degraded characteristics of the wilderness area resume functioning? That is, is there a clear exit strategy—a viable end point, based on identifiable and measurable benchmarks? If the answer to all of these questions is yes, then it may be acceptable to prioritize the need of the natural system for some sort of active intervention to restore ecological functions and processes over the social need to keep wilderness areas perfectly wild and untrammeled.

The National Park Service has undertaken a potentially representative restoration project in Bandelier Wilderness in northern New Mexico. Although the area had been occupied and used for centuries by ancestral Pueblo people, historical data indicates that there was good grass cover and widely spaced, healthy woodlands of piñon and juniper trees. With Euro-American settlement in the nineteenth century, however, came fire suppression and heavy sheep and cattle grazing. President Woodrow Wilson established Bandelier National Monument in 1916 to preserve and protect the area, especially "prehistoric aboriginal ruins" of "unusual ethnologic, scientific, and educational interest." (Proclamation 1916) When Congress took the additional step of designating 23,000-acres (about two-thirds) of the Monument as the Bandelier Wilderness in 1976, the ecological characteristics of the area were by no means pristine and various signs of human occupation remained. (Pub.L. 94-567 1976) By the turn of the twenty-first century, overgrazing and fire suppression had caused "unprecedented change" in Bandelier's piñon-juniper woodlands. An ecological threshold had been crossed. Preventing grazing and other anthropocentric activities would not promote vegetative recovery or curtail soil erosion. Without active management intervention to restore understory plants and to stabilize soils, further deterioration of ecological function would be "highly persistent and irreversible." The Park Service predicted that some areas could lose *all* remaining soil within the next century. (Sydoriak 2000)

Studies in the late 1990s indicated that thinning some trees and using the cut branches as a slash "erosion blanket" on exposed soils generated a three-fold increase in understory cover and a dramatic reduction in erosion. With these studies in mind, the Park Service prepared an

Environmental Impact Statement and adopted a restoration plan in 2007. The plan involves cutting small diameter trees and scattering branches on bare soil on about 4,000 acres within the Bandelier Wilderness. The Park Service decided to use chainsaws, stating that "treatment of such a large area would be infeasible without the use of motorized equipment, and that impacts to monument resources would be substantially reduced through the use of this equipment." (National Park Service 2007) The agency will use hand tools, however, near habitat that could be or is occupied by sensitive or federally listed species. To minimize impacts, the work will take place in the winter when peregrine falcon, bald eagle, and Mexican spotted owl have not yet begun to nest, soils are drier, and fewer visitors are present. Work camps within a three-hour walking distance from Bandelier headquarters will be supplied by mule pack trains. Those in more remote locations will get supplies via helicopter drops, but there will be no landings in the wilderness. For a period of time after the restoration work is completed, prescribed fire may be used to maintain mechanically thinned areas and to promote long term recovery. Park Service staff will monitor each area's response to the restoration activities and will use the information gathered from the treated sites to modify future actions if warranted. (National Park Service 2007)

The thinning/slash option selected by the Park Service was deemed the environmentally preferred alternative, that is, the alternative that "causes the least damage to the biological and physical environment; it also means the alternative which best protects, preserves, and enhances historic, cultural, and natural resources." (Council on Environmental Quality 1987) While the use of hand tools for all of the work would be less intrusive than chainsaws, the Park Service found that it would take twenty times longer to accomplish the restoration and therefore result in substantially greater loss of soils, vegetation, and cultural resources. Likewise, under the no action (no intervention) alternative, ecological degradation would worsen, "with major adverse impacts to the naturalness aspect of wilderness character." (National Park Service 2007)

Why might active restoration be appropriate in Bandelier while it may not be elsewhere? The Bandelier plan appears to meet the wilderness restoration criteria outlined above. First, there is sufficient understanding about the human impacts on reference conditions and processes, as well as the long term effects of restoration actions. Second, experiments and studies had shown that restoration of vegetation and soils would not occur without active intervention but that restoration would be possible with relatively minimal intervention and that ecological functioning and integrity, including biological, chemical, and geophysical characteristics, would improve relatively quickly. (Landres 2004) Finally, humans can disentangle themselves within a discrete period of time and let ecological processes function freely. In Bandelier, the restoration goal will be achieved when there is sufficient understory vegetation to carry naturally occurring fires. (Sydoriak 2000)

Sydoriak provides detail:

> Since most of the soils of the park's piñon-juniper woodlands are over 100,000 years old . . . we can be sure that the natural range of variability in these ecosystems generally allowed for soil development and stability. Controlled, progressive experiments to restore vegetation and prevent soil erosion have taken place within and outside of Bandelier since 1992 and have proven successful. Treatment directly reduces tree competition with herbaceous plants for scarce water and nutrients, and the application of slash residues across the barren interspaces greatly reduces surface water runoff and ameliorates the harsh microclimate at the soil surface, immediately improving water availability for herbaceous plants. This restoration approach has produced a two- to seven-fold increase in total vegetation cover at three years post-treatment and reductions in erosion. Other experimental treatments, such as re-seeding and controlled burns, did not promote understory growth nearly as well. Moreover, evidence of management intervention (in the form of cut marks on small stumps and scattered slash mulch) superficially disappears within roughly ten years depending on site conditions. (Sydoriak 2000)

In contrast, some strategies for active wilderness intervention are too uncertain or too likely to jeopardize complex relationships and processes (Landres 2010), while others have no discernible end point. For example, to diminish acidity caused by air pollution, Forest Service managers used helicopters to dump 140 tons of limestone into streams within the St. Mary's Wilderness in Virginia. The agency recognized that, "The question is whether to allow continued loss of the aquatic biota while preserving the wilderness concept or ideal of 'untrammeled', or compromise the wilderness ideal, to preserve the aquatic resource?" (Forest Service 1998) The intervention worked—albeit briefly—to enhance the wilderness area's "outstanding aquatic resource." Within a few months, stream pH had returned to desirable levels and macroinvertebrate and fish populations began to improve. Within six years, however, the streams were once again experiencing high acidity and the limestone treatment was repeated. (Cole and Yung 2010) The only human intervention that could provide long term benefits for this area is to stop air pollution altogether. Attempting limited yet highly intrusive restoration activities on the ground is a mere band-aid.

Fish eradication and stocking represent another dubious type of restoration intervention. In both the Carson-Iceberg Wilderness of California and the Bob Marshall Wilderness of Montana, federal agencies, in cooperation with state fish and game managers, plan to eradicate introduced, non-native trout by chemically treating wilderness streams with rotenone. In Montana, the agencies hope to clear the way for stocking westslope cutthroat trout—the official state fish—in over twenty high elevation lakes, some of which were historically fishless. Managers plan to use outboard motors, aircraft, and pumps to place their personnel, apply rotenone, and restock the lakes. (U.S. Dept. of Agriculture Flathead National Forest 2006) In California, rotenone would be applied through hand-spraying and drip stations. The end goal is to establish a genetically pure population of threatened Paiute cutthroat trout, which is experiencing hybridization with nonnative trout. (U.S. Dept. of Interior 2010) In addition to rotenone, which kills fish, amphibians, and everything else that absorbs oxygen through gills (Center for Biological Diversity 2003), the area downstream of the treated stream segment will be "neutralized" with potassium permanganate dispensed by a gas-powered generator and auger. The Forest Service determined that "chemical removal of hybridized trout with the piscicide rotenone and the use of motorized equipment (generator and auger) is the minimum activity within Wilderness needed to complete Paiute cutthroat trout restoration." (U.S. Dept. of Agriculture Forest Service 2010) Chemical treatments were planned for three consecutive years, but were ultimately enjoined by a federal district court for violating the Wilderness Act. (Californians for Alternatives to Toxics 2011) Both of the proposed initiatives would involve significant trammeling of the wild with only questionable and likely short-lived benefits for natural processes and function. Neither includes a viable exit strategy. Neither should be undertaken in wilderness.

Similar examples of interventions that are too risky and too likely to harm essential wilderness values while providing little ecological benefit include translocating climate-sensitive species to high elevation and/or northern wilderness areas, where existing communities and ecosystem processes are poorly understood and the means of insuring successful translocation without unintended adverse consequences are limited or non-existent. Additionally, the use of intrusive monitoring techniques such as helicopters to inventory and track translocated or reintroduced species adversely affects not only the species in question but also the surrounding ecosystem as a whole, and is antithetical to the very concept of untrammeled, quiet wilderness. (Wolf Recovery Fnd. 2010) Although monitoring is an essential element of learning and adapting our management approaches, in most cases there are less intrusive means of accomplishing those goals.

Delivering water to bighorn sheep in the desert presents one final example of a human intervention that makes little sense in a wilderness area. (Wilderness Watch 2010) No one wants to see members of an iconic species like bighorn sheep die of thirst. But human and wildlife depredation, disease, habitat degradation, and other stressors are likely contributing to the species' decline, and there do not appear to be effective, comprehensive recovery initiatives that address them in tandem with water shortages. Constructing tanks, pipes, and guzzlers and servicing them with motor vehicles may be the most popular and least costly means of assisting the sheep, but this approach is neither self-sustaining nor resilient. Moreover, like the limestone dumping and fish eradication and stocking programs, there is no viable exit strategy. In sum, water delivery systems involve significant manipulation of wilderness characteristics while providing only short-term benefits for the sheep with few if any long term benefits for natural ecological processes and function.

V. Conclusion: Adapting Human Interventions and Expectations

There are many compelling reasons why wilderness areas should continue to be protected from overt human-dominated manipulations in most circumstances. Intervention into degraded wilderness areas should only be an option if: (1) there is sufficient understanding about reference conditions and processes as well as the long term effects of restoration actions; (2) intervention will more likely than not improve the functioning and integrity of the ecosystem; and (3) humans can extricate themselves within some discrete period of time and let the area's ecological processes resume functioning. If these criteria are met and intervention is undertaken, it should be accomplished with the least intrusive means possible. In addition, secure financial resources must be dedicated to the project, to post-project monitoring, and to further adaptation of the restoration plan where necessary.

Unless we understand a system perfectly—an impossible task—interventions aimed at increasing the stability of the system in a particular historic state may, in fact, increase the fragility of the system and do more damage than the exogenous perturbations that caused the degradation in the first place. Interventions consistent with resilience theory would maintain not the historical state of the wilderness area but rather the essential ecosystem processes that structure the area and enable the wilderness ecosystem to self-organize into a sustainable and wild regime—a collection of mutually reinforcing ecological processes.

In the end, ensuring the resilience of wilderness areas will require humans to be more sophisticated and more adaptive than we have been in the past. Rather than acting as gardeners or, worse yet, curators of museum-like dioramas where managers fight to keep historic features in place, we can be humble yet strategic stewards—guardians—of resilient wilderness areas.

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