

Would Ecological Landscape Restoration Make the Bandelier Wilderness More or Less of a Wilderness?

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Abstract—The purpose of this paper is to foster discussion on the basic issue of whether it is appropriate or not to intervene in designated wilderness areas that have been “trammed by man” and, as a result, no longer retain their “primeval character and influence.” We explore this wilderness management dilemma (whether we can or should actively manage wilderness conditions to restore and protect wilderness and other values) by asking seven questions relating to a wilderness area that is no longer “natural.” (For the purposes of this discussion, “natural” is defined by words and phrases used in the 1964 Wilderness Act: “a community of life untrammelled by man”; “land retaining its primeval character and influence”; and or existing in an “unimpaired condition.”) Debate on this issue is not new, but is intensifying, since most wilderness areas in the continental United States are not pristine and ecosystem research has shown that conditions in many are deteriorating. To facilitate dialog on this wilderness management topic we focus on a case-study of a proposed large-scale project to restore piñon-juniper woodlands in the Bandelier Wilderness, New Mexico.

Many ecosystems in the Bandelier Wilderness (23,000+ acres in Bandelier National Monument, New Mexico) exhibit human-caused damage and unsustainable trends because of a land use history that includes federally sanctioned overgrazing and fire suppression over the past century. This situation has caused park managers and wilderness advocates to ask several important philosophical and practical questions that must be carefully addressed to manage wilderness in general, and the Bandelier Wilderness in particular:

- Does a Park’s enabling legislation (or the National Park Service Organic Act) reign supreme and, if so, at what cost to other resource values, including wilderness values, recognized later in a Park’s history?
- Should federal land managers intervene if wilderness ecosystems are degraded and unsustainable due to the historic activities of motorized societies?
- Can we restore the “natural range of variability” and will it be sustainable?

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- If restoration is possible, what should our goal (target conditions) be in wilderness?
- If current wilderness conditions warrant urgent management attention, are drastic restorative measures justified?
- Is it appropriate to conduct large-scale ecosystem restoration work in wilderness?
- If we start manipulating wilderness to reach an “unimpaired condition” goal, when and where will management intervention end?

Bandelier Wilderness Case Study

A case-study is used to explore, but not definitively answer, these questions. Through these questions, we hope to initiate dialog that will result in informed decisions for the long-term management of Bandelier and other wilderness areas in the National Wilderness Preservation System (NWPS).

Question 1: Does a Park’s enabling legislation (or the National Park Service Organic Act) reign supreme and, if so, at what cost to other resource values, including wilderness values, recognized later in a park’s history?

Question 1 is the easiest to address since the answer is contained within the 1964 Wilderness Act (P.L. 88-577). The act simultaneously limits and permits management action to protect both park and wilderness values (which are arguably the same). In addition, the act makes it clear that wilderness designation does not supercede a park’s enabling legislation or the National Park Service (NPS) Organic Act, but is supplemental to it. Section 4(a)(3) states that: “Nothing in this Act shall modify the statutory authority under which units of the national park system are created. Further, the designation of any area of any park, monument, or other unit of the national park system as a wilderness area pursuant to this Act shall in no manner lower the standards evolved for the use and preservation of such park, monument, or other unit of the national park system in accordance with the Act of August 25, 1916, the statutory authority under which the area was created,....” Section 4(a)(3) makes it clear that the NPS has the legal responsibility to meet its mission requirements and other mandates even in wilderness areas. These provisions are similarly stated for other wilderness management agencies (Section 4(a) and (b)).

In Section 4(b), the act gives the NPS (in this case) responsibility for meeting its mission as well as preserving “wilderness

character.” Unfortunately, wilderness character is not clearly defined and, thus, a dilemma arises for the wilderness ecosystem manager. To some, “wilderness character” means that wilderness areas should evolve in whatever direction nature chooses (be free-willed) after the lands have been designated as wilderness, regardless of pre-existing condition or future consequences. This means that all resource managers (including wilderness/ecosystem restorationists) and researchers should not be permitted to do anything in wilderness using motorized equipment. This position is not wholly supported in the act, as in Section 2(a), the act calls for the preservation, protection and administration of wilderness areas “in such a manner as to leave them unimpaired for future use and enjoyment as wilderness...” Section 4(c) of the act gives the wilderness administrator strong direction to accomplish the preservation and protection task without motorized equipment, but it also permits its use if there is justifiable need “to meet requirements for the administration of the area for the purpose of this Act...”

The 1916 NPS Organic Act dictates that the NPS mission is “to conserve the scenery and the natural and historic objects and the wildlife 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.” Bandelier National Monument (Park, Bandelier), as one of the oldest units in the national park system, was established in 1916 to preserve and protect “prehistoric aboriginal ruins” on the Pajarito Plateau because of their “unusual ethnologic, scientific, and educational” values.

In October 1976, President Gerald Ford signed legislation creating the Bandelier Wilderness, including 23,267 acres. The NPS was initially opposed to this wilderness designation, in part because of a general concern that cultural resources research and management in a “traditional cultural resource park” could be severely constrained. The Bandelier Wilderness was one of the first NPS wilderness areas authorized in New Mexico after passage of the 1964 Wilderness Act. The Bandelier Wilderness, like most wilderness areas in the NWPS, was not pristine when it was created due to a history of harmful EuroAmerican land use practices, yet the public felt strongly that the area belonged in the NWPS (McDonald 1987). Additional wilderness-quality lands were added to the Park in 1977, so that today approximately 71% of the Park is designated wilderness, while more than 90% (about 30,000 acres) is managed as wilderness.

Scientific study in and adjacent to the Bandelier Wilderness since 1987 strongly supports the notion that historic EuroAmerican use of the area has triggered unprecedented change in most Park ecosystems (Allen 1989; Davenport and others 1998); similar changes have occurred throughout much of the Southwest (Allen and others 1998; Bogan and others 1998). For example, federally sanctioned livestock grazing and fire suppression from 1880 through 1932 catalyzed severe accelerated soil erosion across the Park’s extensive mesas that are dominated by piñon-juniper (PJ) woodlands (Gottfried and others 1995; Wilcox and others 1996). These old, relatively shallow soils are the physical matrix for thousands of “aboriginal ruins” that Bandelier National Monument was established to protect beginning in 1916 (Head 1992; unpublished data on file at Bandelier

National Monument). The Bandelier Wilderness contains significant portions of these altered ecosystems and “aboriginal ruins.” Over 90% of the Park’s 11,730 acres of PJ woodlands are within designated wilderness – thus, resolution of any resource issues related to PJ woodlands necessarily involves wilderness considerations. In particular, the majority of documented archeological sites at Bandelier occur in PJ woodland settings (Gottfried and others 1995), and recent extensive and detailed surveys indicate that more than 80% of the PJ archeological sites are being damaged by one or more types of erosion impacts (Head 1992; unpublished data on file at Bandelier National Monument). An estimated 2,500 cultural resource sites located in the Bandelier Wilderness are subject to accelerated erosion-caused damage, or risk of complete loss, within the next century.

The NPS, to accomplish its protection and conservation mandate, must respond to known resource threats within the Bandelier Wilderness. Based on extensive experimentation, it appears that the most effective and least damaging management response to the erosion problem in the Bandelier PJ woodlands will likely require use of motorized equipment (see question 3). However, a minimum tool analysis has yet to be completed for this case-study so the extent of motorized equipment use, if any, is uncertain at this time. In any case, the potential to use motorized equipment to control unnatural rates of erosion appears to be permitted under the provisions of the Wilderness Act, as we demonstrated at the beginning of this discussion.

Question 2: *Should federal land managers intervene if wilderness ecosystems are degraded and unsustainable due to the historic activities of motorized societies?*

The answer to question 2 is a matter of opinion since some agencies and wilderness advocates disagree on the fundamental issue of wilderness ecosystem restoration or management intervention. Let us look at the Bandelier PJ woodlands case-study for some key facts that could influence perspectives on this case.

While some uncertainties persist on the nature of historic ecological changes in PJ woodlands of the Bandelier area, a great deal of research work has been conducted (and continues) on the ecology, hydrology, archeology and land use histories of local woodlands. Synthesizing existing information with published research from other areas, along with consultations with local resource managers and researchers, leads to the following general scenario of changes in the Bandelier PJ woodlands (Allen 1989; Davenport and others 1998; Gottfried and others 1995; Reneau and McDonald 1996).

Woodland soils in Bandelier likely formed, to a large degree, under different vegetation during cooler, moister conditions of the late Pleistocene; in other words, they are over 10,000 years old, and many are over 100,000 years old (McFadden and others 1996). Changes in climate and vegetation in the early Holocene (8,500-6,000 years ago) led to at least localized episodes of soil erosion on adjoining uplands (Reneau and McDonald 1996, Reneau and others 1996). During this time, the dominant climatic and associated vegetation patterns of the modern southwestern United States developed, including PJ woodlands and savannas

(Allen and others 1998). On the basis of local fire history (Allen 1989; Morino and others 1998; Touchan and others 1996), PJ age class (Bandelier National Monument, unpublished data; Julius 1999) and soils data (Davenport 1997; Earth Environmental Consultants 1974; McFadden and others 1996), we believe that Bandelier's PJ woodlands were formerly more open, with well-developed herbaceous understories that: 1) protected the soils from excessive erosion during intense summer thunderstorm events, and 2) provided a largely continuous fuel matrix, which allowed surface fires to spread through the woodland zone from the adjoining ponderosa pine and grassland types.

Native American effects on local woodlands are thought to have been insignificant or highly localized until the late 12th century, when the Ancestral Puebloan (also referred to as the Anasazi) population began to intensively occupy and utilize the Bandelier area (Powers and Orcutt 1999). Cutting and burning of PJ trees for cooking, heating, building and agricultural activities likely led to significant deforestation of upland mesas from about 1150-1550 A.D. Thus, Ancestral Puebloan land use practices favored herbaceous vegetation. Intensive soil disturbance certainly occurred in farmed areas and around habitations, but there was probably little net change in landscape-wide erosion rates due to the small size and dispersed locations of "fields" and villages.

EuroAmerican settlement of the adjoining Rio Grande valley and the introduction of domestic livestock grazing began in 1598. It is unlikely, however, that significant livestock grazing (that is, with substantial effects on the herbaceous understory, fire regime or erosion rates) took place in much of Bandelier until railroads linked the Southwest to commercial markets in the 1880s. Millions of sheep and cattle were placed in the New Mexico landscape at that time (Bogan and others 1998). Livestock grazing was allowed in Bandelier until 1932, and feral burros were similarly allowed to cause grazing impacts until about 1980 (Allen 1989). The resultant high intensity grazing apparently triggered a number of ecological changes in local PJ woodlands. Overgrazing caused sharp reductions in the herbaceous ground cover and associated organic litter, effectively suppressing previously widespread surface fires (in concert with institutionalized fire suppression initiated by the federal government in the early 1900s). Exacerbated by severe drought in the 1950s (Allen and Breshears 1998), the reduced cover of herbaceous vegetation and litter also led to decreased water infiltration and increased surface runoff from the typically intense local rainfall events. Given reduced herbaceous competition and the elimination of surface fires over the past 120 years, fire-sensitive piñon and juniper trees became established in densities unprecedented for at least the past 800 years (Bandelier National Monument, unpublished data; Julius 1999). As these trees grew, they became increasingly effective competitors for water and nutrients. Thus, a positive feedback cycle was initiated that favors tree invasion and decreased herbaceous ground cover in mesa-top settings.

This land use history has caused degraded and unsustainable ecosystem conditions in today's Bandelier Wilderness, particularly the sparsely vegetated and eroding soils that characterize understory patterns in the PJ woodlands. For example, three kilometers of line transect data from Bandelier woodlands in the 1990s document herbaceous plant cover

(basal intercept) of only 0.4 to 9% *versus* exposed bare ground of 38 to 75% (Bandelier National Monument, unpublished data; Gottfried and others 1995), and the intense summer thunderstorms typical of this region result in high rates of runoff and soil erosion (Davenport and others 1998; Reid and others 1999; Wilcox and others 1996a and 1996b). The intercanopy soils of Bandelier's woodlands are apparently eroding at net rates of up to one-half inch per decade (Bandelier National Monument, unpublished data; Earth Environmental Consultants 1974; Wilcox and others 1996a/b). Given soil depths averaging only one to two feet in many areas (Davenport 1997; Wilcox and others 1996a), there will soon be loss of entire soil bodies across extensive areas of the Bandelier Wilderness.

Ecological thresholds have apparently been crossed such that harsh physical processes are now dominant across Bandelier's degraded PJ woodlands (Davenport and others 1998). The loss of organic topsoils, decreased plant-available-water, extreme soil surface temperatures and freeze-thaw activity severely impede herbaceous vegetation establishment and productivity (Davenport and others 1998; Jacobs and Gatewood 1999; Loftin 1999). Reestablishment of herbaceous ground cover under today's desertified mesa-top conditions may also be difficult due to depleted soil seed banks, highly efficient seed predators, particularly harvester ants (Snyderman and Jacobs 1995), and an unnaturally large elk population (Allen 1996b). Herbivore exclosures established in 1975 show that protection from grazing, by itself, fails to promote vegetative recovery in Bandelier's PJ ecosystems (Chong 1992; Potter 1985). Without management intervention, this human-induced episode of accelerated soil erosion appears to be highly persistent and irreversible (Davenport and others 1998).

In conclusion, the present appearance and dominant ecological processes of the Bandelier Wilderness are to a large degree an anthropogenic legacy of the past land use practices of our motorized society. This history includes substantial (though inadvertent) contributions by federal land managers to the current unsustainable situation of accelerated, landscape-wide soil erosion in the PJ woodlands. While a basic tenet of wilderness is that the "imprint of man's work [is] substantially unnoticeable," human impact on essential ecological patterns and processes is profound in the Bandelier Wilderness. If one believes that long-term protection of natural ecosystem function and appearance is important in wilderness, management intervention may be warranted. On the other hand, if one believes that wilderness is defined exclusively by the absence of apparent evidence of human management in the short-term, then management intervention is not warranted in the Bandelier case-study. For additional discussion on this issue see Landres and others in these proceedings.

Question 3: Can we restore the "natural range of variability" and will it be sustainable?

The answer to question 3 lies in scientific study, to define the natural range of variability, and experimentation, to address and test sustainability. Let us look again at the Bandelier PJ woodlands case-study to see what has been discovered.

Since most of the soils of the Park's PJ woodlands are over 100,000 years old (McFadden and others 1996) we can

be sure that the natural range of variability in these ecosystems generally allowed for soil development and stability, rather than the high rates of degradational erosion observed in recent decades. From this fact of long-term soil persistence we can infer that some type of vegetation was protecting the soils from excessive erosion over time, including the last 8000+ years of the Holocene during which a basically modern climatic regime prevailed. We can also determine that herbaceous vegetation must have been the now-missing glue for the soils, given that there is no evidence of formerly closed-canopy woodlands (indeed, the ages of local piñon and juniper trees are largely quite young), and since fire-scar studies show a history of recurrent surface fires that could not have occurred without herbaceous vegetation.

Cessation of domestic livestock grazing in 1932 and removal of feral burros since the 1970s have been insufficient to induce vegetative restoration in degraded woodlands at Bandelier. Ecological thresholds have apparently been crossed, and physical (rather than biological) processes now dominate in Bandelier's PJ woodland areas, precluding recovery to more stable soil/vegetation conditions (Davenport and others 1998). Our research indicates that the Park's PJ woodlands are unlikely to regain any semblance of their pre-1880s condition without management intervention (Davenport and others 1998; Jacobs and Gatewood 1999). Unfortunately, the piñon-juniper ecosystems of the Bandelier Wilderness seem unable to heal themselves.

Fortunately, controlled, progressive experiments within and outside of the Bandelier Wilderness since 1992 (Chong 1993, 1994; Jacobs and Gatewood 1999; Snyderman and Jacobs 1995) have shown (at three years posttreatment) that undesirable losses of soils, herbaceous vegetation and cultural resources can be mitigated through active management, involving use of motorized equipment (chain saws), to thin the smaller trees and leave scattered slash in the form of lopped branches from cut trees. This 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 sevenfold increase in total herbaceous cover (at three years posttreatment), relative to both controls and pretreatment conditions (Jacobs and Gatewood 1999), while also increasing the diversity of herbaceous plants. This tree thinning and scattered slash treatment method is labor intensive and requires extensive use of chain saws to limb and flushcut the PJ trees, given the hard, dense wood of these species (especially juniper) and the large number of trees that require treatment.

Other treatment methods to restore herbaceous ground cover were tested. Seeding in the absence of tree thinning was ineffective, and seeding combined with a thinning/slash treatment conferred little additional benefit. Alternative tree thinning techniques are unlikely to be effective, safe or practical. For example, surface fire cannot currently carry through the barren understory of Bandelier's PJ woodlands; girdling and herbicide treatment do not generate the on-the-ground slash necessary for the creation of microclimatic conditions that facilitate vegetation recovery, as dead trees would be left standing; and exclusive use of non-motorized

tools would take too long, given the urgency of the situation, and also place too many people in the wilderness environment for extended periods, causing other unacceptable wilderness impacts.

In the Bandelier case study, through scientific investigation we are confident that a "range of natural variability" (Landres and others 1999) is reasonably defined. We have also found a seemingly effective restoration technique, but the long-term outcome will only be known as time progresses. The treated areas, though initially dominated by biannual forbs, are becoming increasingly populated by native perennial grasses, which represent more natural conditions. Will the restored herbaceous cover be able to reduce erosion rates to natural, sustainable levels? Based on preliminary data, it appears likely. However, the substantial quantities and distribution of the woody slash/mulch used in this restoration approach are not natural and could support large unnaturally intense fires. The potential for widespread fire can be eliminated by limiting the size of treated areas, and dispersing them across the landscape. The resulting mosaics of fuels and vegetation will provide a margin for error and mitigate aesthetic concerns. Prescribed fire will be introduced to eliminate excessive woody fuel loads and prepare treated areas for naturally occurring fires once adequate herbaceous cover is successfully restored. Experiments will begin in AD 2000 to determine the appropriate timing and prescription for the initial reintroduction of fire.

Question 4: *If restoration is possible, what should our goal (target conditions) be in wilderness?*

Achieving agreement on target conditions can be seen as the crux of the wilderness restoration dilemma. Ideally, target conditions (a range of natural ecosystem structures and naturally functioning processes) exist when a wilderness area is set aside. However, established wildernesses are generally far from pristine—that is, they do not fully retain their "primeval character and influence...." The Bandelier Wilderness provides a well-studied example.

The current resource management vision (desired condition) for Bandelier, including the Bandelier Wilderness, is that:

Natural and cultural resources are promoted and preserved within naturally-functioning and sustainable environmental conditions as existed prior to modern human influence (that is prior to landscape-level livestock grazing and wildfire suppression and following Ancestral Puebloan occupation of the area).

This vision of target conditions for PJ woodlands within Bandelier is functional, as opposed to structural or compositional. In this case, our goal is to have biological processes once again control the rate of erosion and natural fires move across the landscape unimpeded, restoring a natural range of variability. The time it will take to reach sustainability and to test our fire maintenance hypothesis is not yet known. As mentioned in question 3, we have the funds and will initiate restoration-focused fire research in PJ woodlands within and outside of designated wilderness beginning in AD 2000.

Please note that we do not say anything about what the Bandelier Wilderness will "look like" in our target condition statement. The type of experience a person may have in the wilderness is also not defined. We believe these are important omissions because, although wilderness involves scenery and

“human experience” management, it is not necessarily or solely defined by them. Others undoubtedly will disagree with us—thus, the dilemma. Another way of looking at this dilemma is to decide whether management intervention is a form of “trammeling.” Do two trammels, however well intentioned, make a right?

Question 5: *If wilderness conditions warrant urgent management attention, are drastic restorative measures justified?*

The answer to this question, like question 2, is a matter of opinion. The key difference between these questions is question 5's focus on urgency. (The question of magnitude is addressed in question 6.)

Our research data show that the high rates of soil erosion recently measured in Bandelier's PJ woodlands are rapidly degrading the Park's shallow soils and damaging thousands of archeological sites, and that this condition is the result of the actions of a motorized society. We know that delaying or taking no action to mitigate the unnaturally accelerated erosion rates in Bandelier's PJ woodlands will have irreversible adverse consequences for the Park's soils and cultural resources. Every rain event reduces the information-yielding potential of the “aboriginal ruins.” For example, in a single storm on June 29, 1995, 1,040 artifacts were transported off-site and captured in a 1m³ sediment trap at the mouth of a 0.1 hectare catchment basin (Bandelier National Monument, unpublished data). To a significant degree, the Park's biological productivity and cultural resources are literally washing away.

While the Bandelier resource loss data are compelling, we recognize that caution must be exercised when interpreting research findings, given the inherent limitations and uncertainties in all scientific endeavors. For the sake of discussion, however, let's assume that the findings in the Bandelier case-study are scientifically sound and we can be confident that the “natural range of variability” in wilderness conditions, as outlined by Landres and others (1999) and Swetnam and others (1999) is adequately known. Do current conditions and their causes justify taking corrective actions? After all: 1) erosion is a ubiquitous geomorphic process; 2) localized episodes of accelerated erosion have occurred naturally in the past (Reneau and others 1996); and 3) it is impractical to preserve the cultural resource sites at Bandelier in stasis. Further, some Native Americans do not want the NPS manipulating the landscape or archeological sites for any reason, even to stabilize ancestral sites. In addition, some wilderness advocates are understandably concerned about a loss of “wildness” if local land managers have too much latitude to manipulate wilderness resources, even to achieve high-minded and defensible goals.

Given this information, there is no question that we must assess the problem and possible solutions cautiously and responsibly. The decision to implement drastic restoration measures must be made with extreme humility. Yet, it is clear that delays in making this decision in the Bandelier Wilderness come at the cost of ongoing resource loss, since we are losing the intercanopy soils due to high erosion rates and the soils are relatively shallow. Many, eventually thousands, of cultural resource sites will also be damaged or lost since at least 80% of the sites within the PJ woodlands have documented erosion problems.

Societal opinion about large-scale wilderness restoration efforts undoubtedly hinges upon a more complete understanding of the issues and thoughtful evaluation of the potential consequences of alternative actions, including “no action,” to the Bandelier Wilderness and its associated cultural resources. The NEPA process will be used as the primary vehicle through which the NPS and the public will formally assess trade-offs and uncertainties to determine if “drastic restorative measures” to protect cultural resources, soils and ecosystems are justified in the Bandelier Wilderness.

Question 6: *Is it appropriate to conduct large-scale ecosystem restoration work in wilderness?*

The NPS Organic Act and other federal laws mandate protection of park and wilderness resources and values when we know they are threatened (refer to question 1 discussion). In response to these laws, resource management activities such as exotic plant control, application of prescribed fire and wildlife reintroductions are routinely and legally accomplished in federal wilderness areas, as wilderness administration and resource management decisionmaking power are vested to the federal wilderness manager through the 1964 Wilderness Act. None of these laws, including the Wilderness Act, specify that a “no action” decision is justifiable based solely on the magnitude or scale of the possible mitigation alternatives. Therefore, NPS resource managers are obligated to: 1) consciously decide on a course of action when we detect a threat no matter how large or significant, and 2) make responsible decisions about the type and scale of our response to all kinds of resource threats.

The actions proposed for restoration of Bandelier's PJ woodlands will likely require the use of motorized equipment (that is, chain saws). If treated, portions of 8,000 acres of Bandelier Wilderness PJ woodlands will contain scattered evidence of modern peoples, in the form of cut marks on small stumps and scattered slash mulch, for about two decades—the estimated time it will take for natural processes like fire and decomposition to consume the small stumps and slash. Does the large scale of the possible Bandelier Wilderness management action make a difference? From a strictly legal perspective, the answer appears to be “No.” This answer does not make the action ethically correct, however.

The Bandelier Wilderness PJ woodlands restoration project is considered relatively large-scale. Yet, although scale does matter because it affects the cumulative magnitude of the potential effects, the size of the proposed action is not the only important consideration and should not be preeminent in our opinion. A central question in the Bandelier case-study might be: Is a large-scale, management-generated impact of relatively short-term duration acceptable in designated wilderness to restore and sustain “naturalness” or “wildness” and to preserve the prehistoric cultural resources for which Bandelier National Monument was established? Based on our mulch treatment tests, evidence of management intervention superficially disappears within 5 to 10 years depending on site conditions. We hypothesize that if fire is reintroduced to accelerate woody material decomposition and degrade the low flush cut stumps, the evidence of management intervention will be substantially undetectable in 20 years. To deal effectively with the threat

of a wildfire consuming the woody materials too soon after treatment, we must treat the woodlands in patches, thus creating a mosaic of conditions and appearances. Perhaps the duration of the evidence of management intervention matters more than the spatial extent or appearance of that evidence.

Obviously, the answer to question 6, like questions 2 and 5, is a matter of individual perspective, values and opinion.

Question 7: *If we start manipulating wilderness to reach an “unimpaired condition” goal, when and where will management intervention end?*

Question 7 must be answered if management intervention is to be seriously contemplated. There is justifiable public concern that federal wilderness managers could abuse the wilderness resource in the name of ecosystem health restoration. Management intervention should not be a license to control nature, harvest resources or create stasis; it should be a means of facilitating natural healing of motorized societies' impacts to wilderness ecosystems.

We believe that question 7 (along with #'s 3 and 4) can only be addressed through extensive scientific research both to diagnose the health of wilderness ecosystems and to understand the causes of unnatural change. We suggest that management intervention should end when the natural processes present prior to industrial-age humans are once again working in formerly dysfunctional or “impaired” ecosystems. In the Bandelier case-study, based on over 10 years of on-site research, this end point would be achieved when there is sufficient herbaceous cover to carry naturally occurring fires. The herbaceous cover will reduce soil erosion (and cultural resource loss) to natural rates, and fire should maintain the restored herbaceous cover and prevent recurrence of the erosion problem. After restoration, the PJ wilderness ecosystem will be left alone to evolve, driven by natural processes. We submit that this level of restoration would restore important aspects of wildness or “free will” to the Bandelier Wilderness, consistent with the definition of wilderness established in the 1964 Wilderness Act.

Conclusions

One of the penalties of an ecological education is that one lives alone in a world of wounds. Much of the damage inflicted on land is quite invisible to laymen. An ecologist must either harden his shell and make believe that the consequences of science are none of his business, or he must be the doctor who sees the marks of death in a community that believes itself well and does not want to be told otherwise. (Aldo Leopold)

Although there are no simple answers to the wilderness questions presented in this paper, we suggest that a research-based management approach, including identification of a process-oriented goal to achieve an ecologically functional endpoint, sets the stage for making rational decisions about whether and how to intervene when natural conditions do not exist in wilderness areas. As Aldo Leopold pointed out in the quote above (Leopold 1953), we have a choice when we know that the “land is sick.” We can “make believe” that everything will turn out right if nature is left to take its course in our unhealthy wildernesses, or we can intervene to facilitate the healing process.

The Bandelier piñon-juniper woodlands case-study is used in this paper to explore key issues, trade-offs and uncertainties inherent to the wilderness restoration dilemma. While definitive answers are not presented, this case-study is an opportunity for further discussion on an old, thorny and increasingly vital philosophical question: If wilderness managers intervene to restore unnaturally functioning ecosystems, does a designated wilderness area become more or less of a wilderness, as defined under the 1964 Wilderness Act?

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