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REVIEW ARTICLE

Protected area stewardship in the Anthropocene: integrating science, law, and ethics to evaluate proposals for ecological restoration in wilderness

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Every year, the four federal agencies that manage designated wilderness in the United States receive proposals to implement small- and large-scale ecological restorations within the National Wilderness Preservation System. The combination of climate change with other landscape stressors is driving ecological restoration to be one of the single most important, challenging, and potentially litigious wilderness stewardship issues. In addition, different stakeholders may have strongly divergent views about what the right decision should be, and decisions need to go beyond routine technical and scientific analyses to incorporate a broader range of legal and ethical considerations. We present a framework based on a comprehensive, structured set of scientific, legal, and ethical questions to guide the evaluation of proposals for ecological restoration and other types of ecological intervention in wilderness. This framework of questions is a voluntary tool designed to increase communication and transparency among scientists, managers, and interested publics regarding the trade-offs and uncertainties of ecological restoration, and promote informed public deliberation in managing the public resource of wilderness.

Key words: ecological restoration, ethics, intervention, natural, protected areas, stewardship, untrammeled, wilderness

Implications for Practice

- Decisions allowing or denying restoration in wilderness are currently made on a case-by-case basis in the context of scientific uncertainty, ambiguous law and policy, and competing values.
- We present a new, unbiased framework to evaluate proposed ecological restoration in U.S. wilderness based on three sets of questions: scientific (what is the situation?), legal (what can we do?), and ethical (what should we do?).
- This framework will help restoration proponents engage agency staff charged with evaluating their proposal in upfront communication, increasing the likelihood the proposal will be approved.
- This framework will help agency staff make transparent, informed, and virtue-based decisions that comply with the legal mandates of the Wilderness Act and protect the public resource and values of wilderness.

Introduction

Over the last two centuries, humans have increasingly altered the air, water, land, and biodiversity of our planet (e.g. Sample & Bixler 2014). These environmental impacts extend beyond developed areas, influencing the ecological systems of even the most remote protected areas, including the U.S. National Wilderness Preservation System (NWPS; Holsinger et al. 2019), a network of 803 wildernesses across nearly 46 million hectares of public land widely regarded as a cornerstone

of America's conservation portfolio (Belote et al. 2017). In response to ecological degradation, the four federal agencies that manage wilderness—the Department of Interior's Bureau of Land Management (BLM), Fish and Wildlife Service (USFWS), and National Park Service (NPS), and the Department of Agriculture's Forest Service (USFS)—receive proposals from resource professionals in federal and state agencies, universities, non-governmental organizations, and private entities to restore the ecological systems of congressionally designated wilderness in the United States. The reasons for these proposed restorations range, e.g. from removing non-indigenous species to restoring indigenous species populations, and from addressing the effects of climate change to restoring disturbance regimes that have been purposefully altered for decades.

A variety of other ecological interventions not related to restoration but strongly affecting species and ecosystems also

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occur in wilderness, such as reducing predator populations for protecting livestock (Sain Jones 2015), creating water impoundments or diversions for irrigation (Nickas 1999), and introducing nonindigenous game species for sport fishing and hunting (Carter 1997). While focusing on ecological restoration in this article, the issues we discuss and the evaluation framework we present are directly applicable to all ecological interventions that intentionally alter any components or processes of an area (Landres et al. 2015).

Ecological restoration in wilderness raises legal, scientific, and values-based questions that go to the heart of what wilderness is and how it is managed, the role of wilderness in 21st century conservation, and about the moral relationship between people and nature. Debate about the origins and purposes of U.S. wilderness is long-standing (e.g. Rolston 1991; Cronon 1996; Hayes 1996), while debate about the ecological stewardship of U.S. wilderness in the Anthropocene, and restoration in particular, is more recent (Hobbs et al. 2009a; Cole & Yung 2010; Stephenson & Millar 2012; Solomon 2014; Wuerthner et al. 2014; Marris 2015). These same debates about the goals and means of protected area stewardship are occurring worldwide (e.g. Schnitzler 2014; Deary & Warren 2017; Root-Bernstein et al. 2017; Pettorelli et al. 2018). Discussing the effects of impending human-caused ecological changes on the stewardship of protected areas worldwide, Dudley (2011, p. 186), noted that "... we now have both the power and the obligation to make conscious choices about the composition and functioning of natural ecosystems ... [and the] practical and ethical implications of this have scarcely been addressed."

Our intent in this article is not to advocate for or against restoration in wilderness but rather to ensure that the legal mandates of the 1964 Wilderness Act (U.S. Public Law 88–577; hereinafter the Act) are clear and that decisions to approve or deny restoration are based on a transparent consideration of trade-offs grounded in science, law, and ethics. To that end, we first explore the language of the Act and tensions in the purposes for which wilderness is managed, and the resulting dilemma faced by managers. We then review why ecological restoration in wilderness is fraught, synthesizing the existing scientific literature to highlight the dilemmas faced by managers in a world with a changing climate and increasingly dominated by human actions. Next, we analyze the legal constraints in the Act on restoration in designated wilderness, highlighting that the legal regime does give managers flexibility to choose between active and passive management in a range of circumstances, but within important constraints. Finally, we draw on virtue ethics to provide structure for managers making decisions about proposed ecological restorations within the legal mandates of the Act. We conclude with a new framework to help managers evaluate proposed ecological restoration in a way that is systematic, comprehensive, and transparent.

The Dilemma: Preserving Wilderness as Untrammelled and Natural

Designated wilderness in the United States provides an opportunity for restoration not afforded in many other areas because of

its larger size, greater isolation, and relatively intact ecosystems. However, wilderness is managed under the unique and higher standard of protection of the 1964 Wilderness Act, which has also influenced general attitudes toward restoration in the United States. This Act is unique in defining wilderness, in part, as "an area where the earth and its community of life are untrammelled by man" (Section 2c). The four wilderness managing agencies operationally defined untrammelled to mean that wilderness is free from large-scale actions that intentionally alter, hinder, control, or manipulate species composition, patterns of species occurrence and abundance, or processes of an ecological system (Landres et al. 2015). The Act also defines wilderness, in part, as "Federal land ... which is protected and managed so as to preserve its natural conditions," and "generally appears to have been affected primarily by the forces of nature" (Section 2c). In contemporary terms, wilderness would be conceptually described as a relatively unmanipulated area with a high degree of ecological integrity, including its indigenous species, ecological patterns, and processes.

Typically, preserving wilderness as untrammelled and natural are complementary cornerstones of wilderness stewardship. In some situations, however, they conflict with one another, e.g. using piscicides (a trammeling) to remove nonindigenous game fish (to improve naturalness) that were previously stocked in high mountain wilderness, even though these chemicals kill all naturally occurring gill-breathing organisms in the lake (Metcalf et al. 2012). Manipulating an ecosystem to restore it highlights a fundamental tension and dilemma in wilderness stewardship, that is manipulating the ecosystem to protect or restore the natural quality of wilderness by definition compromises the untrammelled quality, while not manipulating (i.e. practicing restraint or hands-off management) preserves the untrammelled quality but may compromise the natural quality of wilderness. Cole (2001) described this dilemma as one of the major concerns that will shape wilderness management in the 21st century. Different people, depending on their backgrounds, interests, and perceptions, may have different perspectives on whether restoration is appropriate or not (Table 1). This tension within the Act is a tension between *how* wilderness is managed and *what* is protected, similar to the general discussion about *means* and *ends* in natural resource management (Camacho 2011). This tension was first described by Graber (1995) and Cole (1996, 2000), and is often characterized as "untrammelled versus naturalness," but several authors (Worf 1996; Landres et al. 2001; Steinhoff 2010; Kammer 2013) emphasize that the Act does not cast these two qualities in terms of "versus" but rather in terms of how to preserve both, despite the inherent challenge.

Support for and concern about ecological restoration in wilderness will likely increase in the coming decades as the combined effects of climate change, the spread of nonindigenous species, and human development increasingly impact natural conditions inside wilderness (DeFries et al. 2007; Stephenson 2014). In the Boundary Waters Canoe Area Wilderness of Minnesota, e.g. the combination of climate change, fire suppression, nonindigenous forest pests, invasive nonindigenous plants, and increasing deer abundance, are causing an ecosystem-type conversion from boreal forest to a mixture of grassland-savanna

Table 1. Opposing simplified perspectives on whether the stewardship goal in wilderness is to preserve untrammeledness or naturalness.

<i>Goal: Preserve Untrammeled Wilderness</i>	<i>Goal: Preserve Naturalness in Wilderness</i>
Manipulation is not justified for any reason, and two wrongs—ecological degradation and subsequent trampling to address degradation—do not make a right	Manipulation is justified because it is our responsibility to correct our past mistakes and impacts to ecological systems
Current problems, although not desired, are deemed acceptable over the long term	Current problems are deemed unacceptable in the short term
Potential results of action may be worse than the results of inaction; do no harm is the first rule until there is sufficient information to act	Potential results of inaction may be worse than the results of action; doing something, even with partial information, is better than doing nothing
Conclusion: There is no target for natural conditions and we watch what happens	Conclusion: There is a target for natural conditions that we are obligated to preserve

and temperate hardwood forest (Frelich & Reich 2009). This transition is occurring throughout the region and is resulting in new combinations of species and ecological processes with unknown functional characteristics. These changes raise significant questions about whether, and how, to take restoration action or to facilitate adaptation to these changes.

Exacerbating the management dilemma over ecological restoration, there is no agency wilderness policy to guide these decisions. As a result, these decisions may be readily influenced by cultural traditions of the agency such as an action bias (Iftekhhar & Pannell 2015) as well as the policy interpretations, values, and belief systems of individual decision-makers (Magness et al. 2012). Furthermore, for a public resource like wilderness, different stakeholders may have markedly different ethical and value-based orientations toward these areas and how they are managed (Alpert 2004). For example, wilderness advocates may feel that the untrammeled mandate outweighs all other factors and therefore any manipulation is inappropriate (Turner 1996; Nickas & Macfarlane 2001), while natural resource specialists may feel that not taking restoration action compromises the ecological integrity of wilderness as a cornerstone of our nation's conservation portfolio (Graber 2003). Making an informed and transparent decision about ecological restoration in wilderness is clearly a “wicked problem” (Head & Alford 2015) that requires understanding intertwined scientific, legal, and value-based ethical factors.

The Scientific Context for Ecological Restoration in Wilderness

Despite their relatively large size and remoteness, all wildernesses are subject to diverse internal and external threats, including transboundary nonindigenous invasive species, air and water pollution, and climate change (Cole & Landres 1996; Sander-son et al. 2002; DeFries et al. 2007; Hansen et al. 2014; Watson et al. 2016). For example, increasing infestations of nonindigenous plants challenge managers of the Frank Church-River of No Return Wilderness, the largest wilderness in the contiguous United States at over 2 million acres (Anderson & Wotring

2001). Rapidly changing disturbance regimes and environmental conditions are forcing more frequent and complex management actions to address issues such as the decline of indigenous species in wilderness (Stephenson & Millar 2012).

Ecological restoration is increasingly used to mitigate the impacts of direct and indirect human activities while simultaneously meeting conservation goals in protected areas (Keenleyside et al. 2012). Although management restraint is emphasized as a statutory goal in wilderness, restoration has been widely implemented across the NWPS. Two recent studies quantified the extent of these restorations. In a 2012–2013 survey of NPS wilderness managers, 34% of the wildernesses reported management actions had been taken to address climate change and its effects (Nelson 2015). Similarly, a 2016 survey of managers from all four NWPS agencies found that ecological restoration and other interventions occurred in 37% of wildernesses from 2011–2015 (Lieberman et al. 2018). Ecological restoration in wilderness varies widely in temporal and spatial scales of application, and in the intensity and frequency of actions (Table 2), but generally is implemented to reduce the abundance and distribution of nonindigenous invasive species, mitigate adverse impacts on indigenous species, and restore indigenous species and ecological processes (Lieberman et al. 2018).

Despite proven benefits of ecological restoration, there are several potential problems with implementation in wilderness. First, several ecological misperceptions or myths persist about wilderness, including cultural stereotypes and beliefs about nature, that have not kept current with advancements in understanding about ecological systems (Table 3). Even though these myths are well known to professional ecologists, they need to be illuminated here because they may underlie a preference for or against restoration action among managers and citizens (Dudley 2011).

Second, managers traditionally relied on historical ecological data to identify sources of degradation, reference conditions, historic range of variability, and intended outcomes. However, because of climate change and other anthropogenic stressors, historical conditions are increasingly viewed as infeasible management targets, although ecosystem legacies remain relevant (Higgs et al. 2014). The emergence of novel ecosystems due to anthropogenic causes is producing new ecological states

Table 2. Examples of restoration and intervention actions to address ecological degradation in designated wilderness, ranging from actions on vegetation, fish and wildlife, soil and water, and fire.

Category	Action and Intended Effect	Location	Reference
Vegetation	Spray herbicide to control nonindigenous plants	Frank Church-River of No Return Wilderness, Idaho	Anderson & Wotring 2001
	Introduce biological control agents to control nonindigenous plants	Theodore Roosevelt Wilderness, North Dakota	Vequist 2007
	Remove indigenous conifers to preserve shrub-grassland habitat for greater sage-grouse (<i>Centrocercus urophasianus</i>)	Multiple wildernesses, Oregon	Baruch-Mordo et al. 2013
Fish and wildlife	Introduce indigenous fish into alpine lakes to increase metapopulation	Multiple wildernesses, California	Knapp et al. 2001
	Introduce wolves (<i>Canis lupus</i>) to augment a naturally declining population	Isle Royale Wilderness, Michigan	Vucetich et al. 2012
	Use piscicide to remove nonindigenous fish prior to reintroduction of indigenous greenback cutthroat trout (<i>Oncorhynchus clarkii stomias</i>)	Mount Massive Wilderness, Colorado	Metcalf et al. 2012
	Reintroduce extirpated indigenous Tule elk (<i>Cervus elaphus nannodes</i>) to create new population	Phillip Burton Wilderness, California	Johnson & Cushman 2007
	Reintroduce extirpated indigenous bighorn sheep (<i>Ovis Canadensis</i>) to create new population	Wheeler Peak Wilderness, New Mexico	Rominger et al. 2004
	Reduce population of indigenous double-crested cormorants (<i>Phalacrocorax auritus</i>) to decrease pressure on native vegetation	West Sister Wilderness, Ohio	Hebert et al. 2005
	Reduce populations of indigenous mountain lions (<i>Puma concolor</i>) to lessen predation on bighorn sheep	Multiple wildernesses, California	Ernest et al. 2002
Water	Provide supplemental water to sustain bighorn sheep and listed Sonoran pronghorn (<i>Antilocapra americana sonoriensis</i>)	Multiple desert wildernesses, Arizona	Dolan 2006
	Add limestone sand to aquatic ecosystems to buffer acidification caused by fossil fuel combustion and restore habitat for native fishes and other organisms	Saint Mary's Wilderness, Virginia	Zellmer 2014
Fire	Thin forests and use prescribed fire to improve habitat conditions for the listed red-cockaded woodpecker (<i>Leuconotopicus borealis</i>)	Okefenokee Wilderness, Georgia	Saenz et al. 2001
	Use prescribed fire to improve habitat conditions for indigenous plant communities	Buffalo National River Wilderness, Arkansas	Vequist 2007

widely seen as having passed a tipping point that makes restoration to the historical trajectory difficult or impossible (Hobbs et al. 2009b). Uncertainties are likely to increase with rapidly changing environmental conditions that may exceed ecological thresholds (Wiens & Hobbs 2015), resulting in unintended or adverse consequences such as ecological surprises (Doak et al. 2008) or enigmatic impacts (Raiter et al. 2014).

To accommodate a dynamic and ever-shifting landscape and climate, restoration efforts are increasingly aiming to foster resilience and ecological integrity, and to maintain desired ecosystem goods and services (Jackson & Hobbs 2009; Wiens & Hobbs 2015). These types of conceptual goals are problematic because they may be ambiguous, difficult to measure, and rarely quantified (Standish et al. 2014). In addition, such broad goals typically are insufficient to address the needs of site-specific restoration proposals in wilderness. Moreover, the implicit assumptions behind these broad goals may not be fully understood (Gregg & Chan 2015). For example, even with relatively well-studied ecosystems and processes, such as the restoration of fire regimes and fuel conditions in ponderosa pine (*Pinus ponderosa*) and mixed-conifer forests of the Rocky

Mountains, the underlying assumptions must be critically examined before any restoration action (Naficy et al. 2016).

Third, ecological restorations may involve uncertainty and risk. For instance, herbicides are used extensively to control nonindigenous invasive plants on public lands in the United States, but very little is known about the scope, efficacy, and cost of this practice (Wagner et al. 2016). These uncertainties underscore the importance of monitoring and evaluation, yet the remoteness of a wilderness setting typically makes these crucial activities difficult and expensive with the result that monitoring and evaluation of outcomes are rarely conducted.

Ultimately, ecological restoration in wilderness requires significant planning and analysis to establish the scientific rationale for action, including consideration of the ecological consequences of not taking restoration action. Essential efforts include identifying the cause and effect of the ecological degradation, defining clear goals for the restoration, and outlining assumptions, uncertainties, and risks. Moreover, wilderness serves as an increasingly scarce benchmark to observe and investigate ecological conditions and dynamics. Since ecological restoration reduces or eliminates the use of wilderness areas

Table 3. Common ecological myths or misperceptions that may influence decisions about the appropriateness of ecological restoration and intervention in designated wilderness.

<i>Myth</i>	<i>Reality</i>
Wilderness is pristine	The word “pristine” is not used in the Wilderness Act. The word pristine means unspoiled or unsullied and the implication is that people spoil nature, but the ecological systems in many wildernesses have been strongly affected by indigenous people long before wilderness designation; in many cases these interactions have influenced what is called today by some as “pristine.” Modern people have a planetary effect and at this point in time no location on our planet is pristine (even without the influence of indigenous people).
People are not part of wilderness	Wilderness is a social and legal construct for the “use and enjoyment as wilderness” by people. Social values affect current goals and practices for managing wilderness. Heritage values—human stories from the land, archeology, indigenous cultural resources and practices, and historical legacies—are an important part of wilderness. Although people are part of wilderness, the goal for designated wilderness is to let nature, not people, dominate the ecological systems.
Nature is in balance if left alone	Ecological systems vary from one place to another and vary over time. Disturbances (such as fire, insects, wind-throw, and landslides) are essential ecosystem processes that have influenced what we see today.
Wilderness ecosystems today should reflect conditions from the time of pre-European settlement	Nearly all ecological systems are constantly changing, albeit sometimes at slow rates of change. It is typically difficult and often practically infeasible to restore an ecosystem to a condition from a single point in time and to maintain that condition over the long term.
Wilderness designation protects ecological systems from further ecological degradation	Many local, regional, and global threats cross the administrative wilderness boundary. Some legally permitted and authorized uses degrade wilderness ecological systems. Nearly all wildernesses are too small to fully encompass the movement of species or the range of ecological processes. Some natural disturbance regimes such as fire are tightly controlled outside wilderness and thereby not allowed to fully play their ecological role inside wilderness.

as a control and the ability to use them as a reference benchmarks, the criteria for allowing restoration should be rigorous, as espoused nearly 40 years ago by Graber (1983).

Balancing the risks, benefits, and uncertainties of ecological restoration in wilderness entails a challenging triage with implications for the economic and social values of wilderness affected by the restoration. For instance, reintroducing extirpated predators such as gray wolves, *Canis lupus*, may have cascading effects on ecological communities (Beschta & Ripple 2016), and over time may influence how the public uses these lands (e.g. recreation, wildlife viewing, hunting) and how they view wilderness stewardship decisions. Ultimately, the scientific context is necessary but not sufficient in making these wilderness stewardship decisions: ecological restoration in wilderness raises questions that also demand weighing legal authorities and constraints, as well as values and ethics.

The Legal Context for Ecological Restoration in Wilderness

A few key sections of the Act delineate the outer limits of agency management discretion in allowing ecological restoration in wilderness. Under Section 4(b) of the Act, an agency managing a wilderness “shall be responsible for preserving the wilderness character” of that area, and any administration of a wilderness shall be done so as “to preserve its wilderness character.” Section 4(c) conditionally prohibits a wide range of activities in wilderness, including temporary roads, motor vehicles,

motorized equipment, mechanical transport, and structures or installations, unless the activities are “necessary to meet minimum requirements for the administration of the area for the purpose of this Act”—which purpose includes, as Section 2(a) makes clear, the protection of an “enduring resource of wilderness.”

Central to understanding the legal constraints on ecological restoration is the Act’s definition of wilderness character (Long & Biber 2014). As noted above, Section 2(c) of the Act defines wilderness as “untrammeled by man” and an area “of undeveloped Federal land retaining its primeval character and influence, without permanent improvements of human habitation, which is protected and managed so as to preserve its natural conditions.” As discussed earlier, not taking restoration action might mean that climate change impacts continue to interfere with the primeval character and natural conditions in wilderness, while taking action might equally undermine their untrammeled status (Aplet & Cole 2010; Camacho 2011). A further challenge is that the underlying terms—untrammeled, primeval, natural conditions—are undefined in the Act and themselves are open to a wide range of interpretation. Operationally, wilderness character is interpreted by the implementing agencies as a combination of five distinct qualities described in Section 2(c) of the Act (Landres et al. 2015).

Given the textual ambiguity of the statute, some of the literature examining the Act has heavily relied on the history of the drafting and enactment of the Act, with a particular emphasis on the perspectives of Howard Zahniser, principal author

of the Act (Scott 2002; Nickas 2004). For instance, Harvey (2005, p. 119) draws on Zahniser's definition of untrammelled to mean that wilderness is "not subjected to human controls and manipulations that hamper the free play of natural forces." However, this legislative history does not provide much assistance in answering questions about the appropriateness of ecological restoration as a means to adapt to climate change or other forces such as encroaching development and habitat fragmentation that are causing significant ecological changes in wilderness. From a legal perspective, moreover, this emphasis on legislative history is problematic. Some legal scholars and judges question whether legislative history should even be relied upon in interpreting statutory language (Manning & Stephenson 2013). In addition, legislative history focuses on the intent of the Congress that enacted the statute—not on the intent and perspectives of those who lobbied Congress for the enactment of the statute. A heavy and singular reliance on Zahniser's perspective is therefore questionable, just as a heavy and singular reliance on the perspective of any lobbyist who has helped draft legislation for Congress is questionable. This is particularly true since the Act was a compromise between the goals of advocates such as Zahniser and the goals of other advocates, such as development interests (Harvey 2005; Turner 2012).

Even where Zahniser and others wrestled with the question of human intervention for restoration purposes in wilderness, they did not squarely address the problems posed by climate change. Zahniser was fairly regular in his opposition to active management in wilderness for extractive, recreational, or aesthetic purposes. But his statements were generally made in the context of assuming that management would change otherwise natural processes. For instance, at one of the Sierra Club Wilderness Conferences where the proponents of the Act developed their arguments and strategies, Zahniser opposed management to restrict erosion in a mountain meadow in a wilderness, if "the process that is going on is natural" (Brower 1964, p. 148). Even in his most famous statement on active management, his article *Guardians Not Gardeners*, Zahniser was responding to a proposal in the famous Leopold Report to maintain a "reasonable illusion of primitive America" and restore parks to pre-European conditions, even if natural forces might cause those parks to move in other directions (Zahniser 1963). Zahniser never explicitly stated what he would recommend if ongoing human influences external to a wilderness, such as climate change, would significantly and continually interfere with natural processes within wilderness.

We are left with fundamental ambiguity in the statute about whether and to what extent active management to address climate change and other anthropogenic threats is consistent with the Act. In the face of that ambiguity, courts generally defer to the expertise of implementing agencies to decide how to resolve it—indeed, courts have often deferred to agency expertise in the past in disputes over whether active management to restore or maintain biodiversity is permissible in wilderness (Long & Biber 2014).

That deference is not boundless, and should not be, since a major concern driving the enactment of the Act was suspicion of whether agencies would be consistent, long-term protectors

of wilderness character. Judicial precedent and the text of the statute give us a sense of the outer limits of that discretion. First, permanent roads and most commercial activities are flatly prohibited by Section 4(c). Second, actions that are conditionally prohibited except "as necessary to meet minimum requirements for the administration of the area" under Section 4(c) can only be allowed if it can be shown that they are necessary to achieve a wilderness purpose, and that they will have the minimum possible impact on other wilderness values.

Third, case law makes clear that it is a permissible goal under the Act for an agency to restore and protect indigenous biodiversity and ecosystems in wilderness where those resources have been adversely impacted by human actions (Long & Biber 2014). This is true either because such restoration efforts are part of maintaining wilderness character, and so consistent with that goal of the Act, or because restoration of indigenous biodiversity and wildlife is an additional purpose of the Act recognized in Section 2(b). Similarly, Section 4(d)(1) of the Act allows the agency to take "such measures . . . as may be necessary in the control of fire, insects, and diseases" in wilderness—though the agency must make the same findings of necessity and minimum impact as required under Section 4(c).

Fourth, Section 4(b) of the Act mandates that any agency action—whether using tools that are regulated by 4(c) of the Act or not—must avoid degrading wilderness character. For example, even using hand saws, an agency could not clear-cut a wilderness. However, the restrictions on the use of all management actions under Section 4(b) should be no more restrictive than the same tests applied to conditionally prohibited tools under Section 4(c).

Finally, the Act likely allows active management not just to restore and maintain historic or existing conditions for indigenous biodiversity and ecosystems, but in limited circumstances also to facilitate transitions to new ecosystem states—for instance, assisted migration of a species from current habitat to new habitat that would be suitable in a new climate regime (Long & Biber 2014). Such action in wilderness can only be justified where the agency can establish that the wilderness would otherwise transition on its own to the new state as a result of climate change and that other forms of human interventions prevent that transition from occurring. For instance, assisted migration might be permissible if the agency can demonstrate that the species would migrate on its own into the wilderness, but for intervening human development of lands between its current habitat and the new habitat in the wilderness.

We emphasize three crucial limitations to this agency discretion. First, the agency cannot pursue restoration that has the purpose or effect of advancing commercial interests in wilderness, particularly exploitative interests such as commercial logging. Second, the agency must make appropriate findings about how restoration advances the goals of the Act, especially the long-term preservation of wilderness character, and demonstrate that the use of prohibited tools or activities are necessary and have minimum impacts. Third, just because restoration may be legal under the Act does not mean that it is ecologically or ethically appropriate. The Act sets the outer bounds of what is permissible under the law, but ecological constraints and ethical

Table 4. Overview of ecological restoration and intervention actions, including climate change adaptation, that are legally prohibited or permissible in designated wilderness.

<i>Legally Prohibited or Permissible?</i>	<i>Action</i>
Clearly prohibited	Permanent roads, most commercial activities.
Possibly permitted	Use of tools or activities conditionally prohibited by Section 4(c) to facilitate transition to new ecosystem states; must make findings that tools are necessary and have minimum impact uses. Use of tools/activities not covered by Section 4(c) to facilitate inevitable (or otherwise occurring) transition to new ecosystem states, consistent with the mandate of Section 4(b).
Likely permitted	Use of tools/activities conditionally prohibited by Section 4(c) to restore or protect existing biodiversity and ecosystems; must make finding that tools are necessary and have minimum impact.
Clearly permitted	Use of tools/activities not covered by Section 4(c) to restore or protect existing biodiversity and ecosystems, consistent with the mandate of Section 4(b). Agency choice to do nothing to respond to climate change impacts on wilderness resources. Passive management (e.g. expanding protected area size, reducing other human stressors).

considerations may lead agencies and managers to not undertake active management in wilderness even if they might be able to legally justify those choices (Table 4).

The Ethical Context for Ecological Restoration in Wilderness

The scientific and legal sections raise several issues that are philosophical and ethical in nature. Because preserving both untrammelled and natural conditions is mandated by the Act but action to preserve one may degrade the other, this tension, at its core, is an ethical dilemma. Ethical dilemmas in public land management require greater levels of transparency in decision-making to make sure all stakeholder views and values are addressed (Hourdequin et al. 2012) and appropriate objectives, goals, and policies are implemented (Artelle et al. 2018). Because any management action, especially ecological restoration, necessarily prioritizes some values at the expense of others, it is critical to state the terms of this dilemma clearly, examine who and what benefits and who and what does not, and the likely short-term and long-term consequences of the restoration actions. Faced with legal ambiguity and increasing effects on wilderness from climate change and other widespread anthropogenic effects, the rise of novel ecosystems, and future uncertainty about the efficacy of restoration, it is incumbent upon the restoration proponents to articulate clearly and upfront the values at stake and potential trade-offs before restoration is implemented. Transparency per se is a key ethical criterion, and upfront analysis of the trade-offs among these values fosters transparency in the ultimate decision.

Some of the philosophical debates within the field of ecological restoration help frame the ethical questions about ecological restoration in wilderness. Katz (1992, 2000) expressed concerns that restoration could lead to a slippery slope of increasingly anthropocentric and anthropogenically shaped landscapes. Reinforcing the need for ethical and moral clarity, Higgs (1997, p. 338) stated that restoration practitioners who focus solely on ecological criteria and economic efficiency “produce an

effective restoration, which is a necessary but not sufficient condition of good restoration.” Higgs asserted that practitioners too often focus attention on restoration as a product, while ignoring or obscuring important moral dimensions of restoration as a process involving multiple stakeholders with diverse values and interests. According to Higgs (1997, p. 347), principles of good restoration must expand to include historical, cultural, social, political, aesthetic, and moral factors within “an inclusive process for making decisions about the design, implementation, and management of restorations.”

To help resolve the ethical dilemma over ecological restoration in wilderness, environmental pragmatism (Light & Katz 1996; Light 2000) guided by virtue ethics (Sandler & Cafaro 2005) is a useful framing heuristic. Environmental virtue ethics can provide “sensitivity to values and context (i.e. wisdom) that is ... often instrumental in the application of action-guiding rules and principles to concrete situations” (Sandler 2013, p. 7). Environmental pragmatism recognizes that a plurality of values are typically at play in contentious decisions, and seeks practical solutions that incorporate a consensus of shared values. For example, Kelly (2018) describes how the “product” and “process” values of different stakeholders contribute to contention over ecological restoration in wilderness, even though each is part of the other: untrammelled nature allows the evolution and persistence of indigenous species, and indigenous species are an essential component of the pattern and process of untrammelled nature.

Virtue ethics asks which virtues or positive traits shape our actions. With respect to ecological restoration in wilderness, virtue ethics recommends prioritizing values that reflect the language and spirit of the Act and how these in turn can guide management decisions. A virtue ethics approach asks, how can wilderness survive and flourish in times of rapid and threatening ecological and social change (Thompson & Bendik-Keymer 2012)? How can individuals become more attuned to the values of wilderness character as framed in the Act? Which virtues and values should guide and be reflected in management decisions when managers are faced with increasing pressures for restoration actions in wilderness?

Viewed through the lens of virtue ethics, proposals for ecological restoration in wilderness may fall into the category of “benevolent restorations,” that is, actions undertaken to remedy past harms to nature so that nature can once again evolve largely free from human constraints (Light 2000). Rather than exemplifying hubris, benevolent restorations are a form of restitution, taking responsibility for previous harms to nature and respecting nature’s ability to evolve free from undue human influence. However, the mandate in the Act to manage for both the untrammled and natural qualities of wilderness character further problematizes this. When can restoration in wilderness, which necessarily degrades the untrammled quality of wilderness, also be considered good restoration?

A key consideration is keeping restoration tethered to the important virtues of humility, patience, and restraint (Higgs 2012; Throop 2012) that express the spirit of the Act. These virtues constrain management actions and prevent restoration from becoming simply one more activity that reshapes the natural world in our interests. For wilderness in particular, as the most restrictively managed public lands, the bar for restoration should be set higher than in other public lands.

Based on this high bar, one management approach argues that restraint—untrammledness—should be the default position in wilderness, and only when other criteria are met should management actions such as restoration be considered (Landres 2010). The virtues of restraint, humility, and patience undergird untrammledness as the *prima facie* ethical position, requiring compelling ethical reasons to override and intervene in wilderness. Here the object is to restrain human impulses to intervene in order “to let nature ‘roll the dice’ and accept the results with interest and scientific curiosity” (Lucas 1973, p. 151), fully respecting the autonomy of wild nature even when this may mean losing other things of value. It suggests that managers work with nature’s resilience, incorporating the virtues of humility, patience, and restraint in management actions (Throop 2012).

Yet while respect for the untrammled quality of wilderness should be seen as the default ethical position, it is not absolute: other compelling ethical reasons may override it and call for restoration in specific cases. Advocates for restoration in wilderness in Bandelier National Monument, e.g. pointed to the need to protect over 2,500 archeological sites threatened by rapid soil erosion due to anthropogenic loss of grasslands and ground cover. Here, restoring the natural character of wilderness was essential to protecting cultural values; leaving the area untrammled would have meant accepting the loss of valuable archeological sites whose protection was central to the designation of Bandelier as a National Monument and wilderness (Sydoriak et al. 2000). Similarly, protection of endangered species and ecosystems, protection of populations or ecosystems with important cultural values (e.g. groves of giant sequoia, *Sequoiadendron giganteum*), and maintenance of important ecosystem services such as watersheds that support drinking water sources may warrant restoration.

Managing for the untrammled character of wilderness as the default position also addresses concern for slippery slope

effects. Once the untrammled threshold has been breached in favor of action to restore naturalness, it becomes increasingly difficult to reject future restoration proposals. No one intends to use restoration as a means to degrade wilderness character, but cumulative effects of many actions taken under increasing pressure to reverse anthropogenic degradation can unintentionally undermine wilderness character and turn wildernesses into a patchwork of highly managed sites. Here the restoration virtues of humility, patience, and restraint become ever more relevant for managers considering ecological restoration.

As the cumulative effects of climate change and the emergence of novel ecosystems increase, so will the pressure to intervene in wilderness to protect, preserve, or restore perceived natural conditions or other things we value. Left unchecked, we face the ironic possibility that wilderness becomes intensively managed, jeopardizing the very wild character that makes these places distinct. Already with the recognition of novel ecosystems there is growing pressure to bypass restoration and instead manage primarily for ecosystem function and services (Hulvey et al. 2013; Starzomski 2013), thereby abdicating both the wilderness values of untrammledness and naturalness.

Wilderness management framed by environmental pragmatism and inspired by virtue ethics is rooted in both the spirit and intent of the Act. It highlights the virtues of attentiveness, respect, patience, and humility that reflect the values and spirit of the Act in making management decisions. This ethical foundation guides the proposed evaluation framework that follows.

Asking the Right Questions: A Framework to Evaluate Proposals for Ecological Restoration in U.S. Wilderness

Ideally, concern about ecological restoration in wilderness would compel public debate and collaborative discussions leading to revised agency policies to guide consistent and appropriate management direction. However, this societal discussion and policy direction is lacking, and wilderness managers and resource professionals need immediate help to address the interwoven scientific, legal, and ethical factors discussed above.

When faced with ecological degradation, whether the presence of a nonindigenous species, the decline of indigenous species, or resource degradation from climate change or anthropogenic factors, agency staff commonly ask, “How can I fix this?” reflecting what Holling and Meffe (1996) described as an agency culture of command and control. Proposals for ecological restoration in wilderness, however, must meet the statutory mandates of the Act, requiring that agency staff, including both wilderness and natural resource professionals, ask additional questions that are much harder to answer. These other questions come from a nuanced understanding of the statutory mandates for managing wilderness, relatively recent ecological understanding of climate change, novel ecosystems, historicity, resilience, ecological surprise, and recognizing the importance of collaborative processes and virtue ethics. In short, avoiding asking the wrong question such as how can I fix this? and asking the right questions is of paramount importance in

Table 5. A framework of sequential and pragmatic questions to guide the evaluation of proposals for ecological restoration and intervention actions in U.S. wilderness. An explanation for the answer is required for all questions, even for those that could be directly answered with a single-word response such as “yes” or “no.”

Category	Questions
Scientific questions: what is the situation?	<p>What is the historic background for the ecological degradation, and was it caused by past human actions or legacy land use impacts?</p> <p>What is the current ecological degradation, and is it within the range of historic variation for this system?</p> <p>Are current human actions preventing natural ecological recovery?</p> <p>Is the cause of ecological degradation local, regional, or global (such as climate change)?</p> <p>What are the cascading ecological effects of the degradation, and how quickly are these impacts likely to occur?</p> <p>What are the anticipated short- and long-term ecological outcomes of not restoring or intervening?</p> <p>What is the intended ecological outcome of the restoration or intervention: to restore to historic conditions, maintain current conditions, facilitate adaptation to new conditions, or other goal?</p> <p>What types of restoration or intervention activities are being proposed, and what is the spatial and temporal scale of these activities?</p> <p>Are the proposed actions based on previous site-specific experience and techniques?</p> <p>Are monitoring and evaluation of results included as part of the proposed restoration or intervention?</p>
Legal questions: what can we do?	<p>Do the proposed actions degrade wilderness character in violation of Section 4(b) of the Wilderness Act?</p> <p>Do the proposed actions involve activities prohibited or regulated by Section 4(c) of the Wilderness Act?</p> <p>Do the proposed actions seek to restore or protect existing biodiversity or ecosystems, or seek to facilitate transition to a new ecosystem state?</p> <p>Do the proposed actions satisfy specific provisions of wilderness legislation?</p> <p>Do the proposed actions directly or indirectly advance a commercial service?</p> <p>Are the proposed actions required to satisfy provisions of other legislation, such as the Endangered Species Act?</p> <p>Do the proposed actions fulfill or comply with requirements of judicial rulings that apply to the management area?</p> <p>Has the appropriate decision-making jurisdiction and authority within the agency been determined?</p> <p>Is formal consultation and permitting with another agency or with tribes/indigenous groups required?</p> <p>Does other agency direction such as policies, management plans, or special orders (including Executive Orders) influence the decision on the proposed restoration or intervention actions?</p>
Ethical questions: what should we do?	<p>Why do the proposed actions need to occur in this particular wilderness and why do these actions need to occur now?</p> <p>Has the managerial responsibility to preserve the untrammeled quality of wilderness been seriously considered?</p> <p>What are the potential short- and long-term effects of the proposed actions on wilderness character?</p> <p>Would the proposed restoration or intervention require repeated actions over time to be effective?</p> <p>What are the cumulative effects of the restoration or intervention actions on wilderness character, in combination with the effects of administrative, scientific, commercial, and visitor use?</p> <p>Are indigenous cultural values and traditional ecological knowledge relevant to the proposed restoration or intervention?</p> <p>Who are the likely stakeholders, and has the anticipated range of views on the proposed restoration or intervention been seriously considered?</p> <p>What are the trade-offs in the effects of the restoration or intervention on the qualities of wilderness character, including rare or valued aspects of wilderness character, and trade-offs between natural and cultural resources?</p>

developing and evaluating proposals for ecological restoration in wilderness.

Here, we provide a comprehensive and systematically structured framework of interdisciplinary questions as a guide to wilderness managers in evaluating proposals for ecological restoration in wilderness (Table 5). Importantly, this framework of questions could also be used as an aid to natural resource professionals in developing their restoration proposal to ensure that their proposal addresses the evaluation questions. This framework is structured around three fundamental considerations: a set of scientific questions examining “what is the situation,” a set of legal questions examining “what can we do,” and a set of ethical questions examining “what should we do.”

The scientific questions explore understanding of the ecological degradation and the proposed restoration, including the historical context and cause, restoration goals, and implementation methods. The legal questions explore compliance with the Wilderness Act and other federal statutes, judicial rulings, and other administrative direction. Finally, the ethical questions explore consideration of impacts unique to wilderness (e.g. effects on wilderness character) and whether and how stakeholder values have been addressed. Together, these three sets of questions are intended to elicit a complete description of the scientific, legal, and ethical basis for the proposed restoration, including consideration of the potential consequences of not taking action, and all underlying assumptions.

This framework was developed by an interdisciplinary team composed of agency decision makers and resource specialists from all four wilderness managing agencies, and university faculty specializing in ecological restoration and ethics. The set of questions and their wording is purposefully unbiased, i.e. the evaluation framework is neither for nor against restoration, because, as described in detail above, some restorations are appropriate while others are not and only an objective evaluation can render this determination. Although some of the questions could be answered with a single word such as “yes” or “no,” an explanation for the answer is required for all questions. The framework was developed based on principles of structured decision-making, including problem structuring and analysis, and early consideration of diverse stakeholder views (Marcot et al. 2012). An initial framework of questions was pilot tested on-site with agency staff and their partners across the four wilderness managing agencies in 16 geographically and ecologically diverse wildernesses to evaluate a broad range of existing restoration proposals. Following pilot testing, the framework was revised and reviewed by the original interdisciplinary team, and then widely reviewed by stakeholders from the agency, academic, and advocacy communities.

The framework presented here is intended to be applied on a case-by-case basis, and therefore it does not guarantee consistent project-level decisions within an agency or across the NWPS, nor is it intended to develop or guide agency policy. A few questions appear similar and occur in two of the main sets of questions (e.g. “What is the intended ecological outcome of the restoration: to restore to historic conditions, maintain current conditions, or facilitate adaptation to new conditions?” occurs in the scientific set, while “Does the restoration seek to restore or protect existing biodiversity or ecosystems, or seek to facilitate transition to a new ecosystem state?” occurs in the legal set). In these cases, the question is intended to be asked and answered from the perspective of the set that it occurs in. Furthermore, some questions may not be relevant or applicable in some situations, but this determination needs to be made on a case-by-case basis and the reason for not using a particular question should be documented as part of the evaluation process.

This evaluation framework is a voluntary tool designed to improve communication among staff within the NWPS agencies, and between the NWPS agencies and their partners and the public. In contrast to many natural resource management tools that limit considerations to ecological factors, this framework explicitly incorporates law and policy, as well as stakeholder values. This framework does not try to change the values, attitudes, or behaviors of agency staff or other stakeholders; rather this framework provides what Heberlein (2012) identifies as a “structural fix” to help make explicit the assumptions that may lie at the core of proposals for ecological restoration in wilderness. By integrating legal requirements and anticipating the range of stakeholder values in the evaluation of wilderness restoration proposals, managers can more easily identify key uncertainties, as well as potential future conflicts and litigation (Ives & Kendal 2014).

This evaluation framework may be criticized as adding too much complexity, time, and effort to ecological restoration in

protected areas. This criticism, however, ignores several factors. First, there is a higher legal and ethical standard for restoration in protected areas, especially designated wilderness, and this higher standard demands greater care. Second, as protected areas and wilderness become increasingly remnant in our increasingly developed world, there will likely be greater scrutiny on proposed actions in these areas to ensure that the actions are appropriate. Third, a higher standard and greater scrutiny have led to increasing administrative appeals and litigation over proposed restoration actions. Fourth, international restoration practitioners may assert that this evaluation framework does not apply outside the United States, but the framework presents basic principles that apply to restoration actions in all countries. In summary, this evaluation framework is functionally a checklist promoting upfront discussion to improve protection of wilderness resources and values, just as a surgical checklist takes time and effort but ensures due diligence and has been shown to markedly improve outcomes (Gawande 2011).

Ultimately, use of this framework fosters a transparent and informed decision on proposed ecological restorations grounded in an integrated evaluation of scientific, legal, and ethical considerations. In addition, if used by restoration proponents in developing their proposal, the framework would help promote upfront communication between proponents and wilderness or other agency staff charged with reviewing these proposals. Lieberman et al. (2018) recommended that these decisions and the reasons for approving or denying proposed restorations be formally tracked in agency reporting. If used widely, this framework could provide a consistent basis for tracking and reporting on these decisions.

Conclusions

Wilderness management decisions on ecological restoration are currently made in the context of scientific uncertainty, ambiguous law and policy, and competing values. The management dilemmas posed by climate change and other human impacts in the Anthropocene will likely become more numerous and intense, and the Act allows managers to adopt a range of responses to those dilemmas. While there are many evaluation frameworks that rely solely on scientific criteria, making decisions based on science alone is not sufficient for wilderness stewardship: the structured framework presented here integrates questions that represent the complex trade-offs among different objectives, values, and stakeholders related to ecological restoration in wilderness. In particular, this framework complies with the legal mandates of the Wilderness Act while promoting increased communication and transparency of the trade-offs and uncertainties regarding the benefits and risks of restoration in wilderness, and promotes a deliberate and thoughtful virtue-based approach to managing the public resource and values of wilderness.

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