

RESEARCH NEEDS FOR MANAGING NON-NATIVE SPECIES IN WILDERNESS AREAS

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The Aldo Leopold Wilderness Research Institute (Leopold Institute) develops and communicates knowledge needed to manage wilderness for the protection of its unique ecological and social values. In its 1996 Strategic Plan, the Leopold Institute identified non-native species, fire, and recreation as its three highest-priority wilderness research issues. This document was developed to guide scientists (agency, university, or private) conducting or planning to conduct research on non-native species in wilderness. We provide a general list of high-priority research questions that are relevant to understanding and managing non-native plants, animals, and pathogens throughout the wilderness system. This list has been reviewed by 17 individuals, including wilderness managers and agency and university scientists.

BACKGROUND

Wilderness and similarly managed areas (e.g., many National Parks), hereafter collectively referred to as “wilderness,” provide many benefits to society. These benefits include the protection of biodiversity, unique natural features, and watersheds, as well as opportunities for recreation and personal fulfillment. Although land management agencies place a high priority on wilderness protection, some wilderness benefits are threatened by increasing levels of human activity within and outside wilderness. The introduction of non-native species into wilderness, intentionally or unintentionally, is of particular concern due to the potential for irreversible impacts on natural systems. These impacts include the loss of native biodiversity, alteration of ecosystem processes (e.g., fire regimes, hydrology, and nutrient cycling), and reduction in the quality of wilderness recreation experiences (Cox 1999, Osborn et al. 2002). This document identifies priority research needs to improve our understanding of and ability to minimize the impacts of non-native plant, animal, and pathogen species within both wilderness terrestrial and aquatic habitats.

Even using the best possible science, non-native species management in wilderness is complicated. First, wilderness areas are typically remote and difficult to access, making non-native species management a logistical problem. Second, the 1964 Wilderness Act (Public Law 88-577) does not provide clear direction. The Act mandates that wilderness must be maintained in both a natural condition and an “untrammeled” condition (i.e., free from human manipulation and control). A conflict between the two mandates occurs when control or eradication of non-native species (i.e., restoring natural conditions) requires human manipulation of the wilderness

ecosystem. Third, establishing management goals (e.g., desired future conditions) and deciding which management approaches to implement are value-laden processes. Philosophical and ethical considerations are important components of these processes. Fourth, and perhaps most importantly, public awareness of the magnitude of the non-native species problem, both within and outside of wilderness, remains low. Increased public awareness should lead to greater efforts by wilderness users to minimize the introduction and spread of non-native species, as well as greater support for laws and regulations to reduce their introduction and spread nationwide.

RESEARCH QUESTIONS

We group pertinent research questions into three topical areas:

- Understanding the introduction, spread, and distribution of non-native species within wilderness.
- Understanding the effects of non-native species on wilderness values.
- Identifying and evaluating management options and their consequences.

Within each topic, we briefly present background information followed by a list of proposed research questions. For the last two topics, we further divide the questions into ecological and social categories because successful protected area management requires knowledge of both biological and social factors (Mascia et al. 2003).

Among the diverse wilderness areas in the U.S., the specific threats posed by non-native species and the appropriateness and efficacy of various management responses may vary greatly. Thus, we do not attempt to identify site-specific research questions or to rank our suggested research questions.

Understanding the introduction, spread, and distribution of non-native species within wilderness

Non-native species have been introduced, both intentionally and unintentionally, into wilderness. Some species have been intentionally stocked within wilderness or on adjacent lands to provide increased fishing and hunting opportunities, while others have been intentionally introduced to slow erosion following fires. Conversely, many non-native species, especially plants, have been unintentionally introduced and dispersed by a variety of agents. Dispersal agents can be human-associated (e.g., recreationists, pack stock, livestock) or natural (e.g., wind, water, wildlife). Management efforts (e.g., requiring the use of weed-free hay) are commonly taken to disrupt these dispersal vectors, but their effectiveness is largely unknown.

Depending on the relative importance of different dispersal vectors and the resistance of different sites to invasions, certain areas within wilderness (e.g., disturbed sites, trail and river corridors, near wilderness boundaries) are usually more susceptible to invasions than others (Osborn et al. 2002). To more efficiently detect non-native species within vast areas of land, managers would benefit from an improved ability to prioritize areas for inventory and monitoring. Data exist on the mechanisms and most probable locations of introduction and spread for some wilderness areas, but information for a wider range of wilderness areas is needed.

Environmental disturbance can promote the establishment of non-native plants by temporarily eliminating native competitors, increasing resource availability, or both (Stohlgren et al. 1998). Based on knowledge that fire is essential to many wilderness ecosystems, however, some managers are attempting to restore historical fire regimes by allowing natural fires to burn or by setting prescribed fires. A better understanding of the process of establishment by non-native species after fire may enable managers to restore fire while employing methods to minimize the spread of non-native species. Other natural disturbances such as windstorms, insect and pathogen outbreaks, and floods may also facilitate the spread of non-native species. Control and restoration techniques that favor establishment of native species after disturbance need development and evaluation.

In addition to disturbance, other factors can influence a wilderness area's vulnerability to invasion by non-native species. The biophysical elements of a wilderness, such as the structure and composition of plant communities, soils, and climate, could be important factors. A wilderness area's position within a landscape matrix of more intensively developed lands may also be important, requiring the consideration of factors such as surrounding land use practices, proximity to major roads and cities, and wilderness area dimensions. Finally, some wilderness areas may be subject to large-scale human disturbances within their boundaries, such as mining activities on historic claims or forest-thinning activities undertaken to reduce the potential for wildfires or pathogen outbreaks.

Effective management of non-native species requires scientifically sound survey, mapping, and monitoring procedures to detect new occurrences, determine rates and direction of spread, and assess the results of management actions. Most wilderness managers, however, are unable to support such programs because they lack the funding and personnel to thoroughly survey what are often large, remote areas (Marler 2000). With respect to invasive plants, remote-sensing and Geographic Information System (GIS) technologies have been used to map large populations (Everitt et al. 1996) or to prioritize locations for field surveys (Dewey et al. 1991) because remote-sensing methods may lack the sensitivity to detect small initial populations. Further research to develop and improve a range of inventory and monitoring techniques at multiple scales is needed.

Priority research questions on introduction, distribution, and spread include:

- Which dispersal vectors are most important for spreading non-native species into wilderness? How can they be most effectively disrupted?
- How can historic disturbance regimes (e.g., fire) be restored to wilderness while minimizing the establishment or spread of non-native species?
- To what extent do non-native species established in wilderness facilitate the colonization of additional non-native species?
- To what extent do historic and existing "special provision" land-use practices (e.g., grazing, mining, water development projects) within wilderness influence invasions?

- To what extent do the biotic (e.g., vegetation types and conditions) and abiotic (e.g., soils, climate) characteristics of a wilderness influence invasions?
- To what extent does the landscape context of a wilderness (e.g., land use practices adjacent to the wilderness, wilderness dimensions, proximity to major roads and cities) influence invasions?
- How can we accurately and efficiently assess the current distribution and abundance of non-native species in wilderness? How rapidly are they being introduced and spreading?
- How can managers determine the best locations for field surveys to monitor non-native species in wilderness?
- How can remote-sensing methods for detecting and mapping non-native species in wilderness be further utilized and improved?

Understanding the effects of non-native species on wilderness values

ECOLOGICAL VALUES

Wilderness areas serve as ecological reference areas for native ecosystems and often provide critical habitat for threatened and endangered species. These ecological benefits may be compromised, however, by non-native species that compete with, prey upon, or cause disease in native species or by those that alter ecosystem processes to the detriment of native species. A few examples illustrate the potential severity of impacts in wilderness. At Hawaii Volcanoes National Park, firetree (*Myrica faya*) increased the available soil nitrogen, thereby facilitating the establishment of non-native earthworms and plants (Vitousek and Walker 1989). Throughout the western U.S., plants such as cheatgrass, Lehmann lovegrass, and saltcedar have increased the frequency of fire, reinforcing their dominance over native plants and reducing habitat for native wildlife (Cox 1999). At Flathead Lake in Montana, introduced opossum shrimp (*Mysis relicta*) precipitated the collapse of the kokanee salmon (*Oncorhynchus nerka*) population. The salmon were an important food resource for migrating bald eagles (*Haliaeetus leucocephalus*) along a tributary stream in Glacier National Park (Spencer et al. 1991).

Considerable data exist on the ecological effects of non-native species, and such effects remain the focus of ongoing research. Nevertheless, further research is needed to understand the impact to ecosystems and species that are largely restricted to or dependent upon wilderness areas. For example, the introduction of non-native fish into wilderness alpine lakes may alter ecosystem processes and threaten native amphibians with extirpation (Pilliod and Peterson 2001, Schindler et al. 2001). White pine blister rust, an introduced pathogen, decimates whitebark pine (*Pinus albicaulis*) populations found largely in wilderness (McCool and Freimund 2001). In some locations, whitebark pine is a critical food resource for the grizzly bear (*Ursus arctos horribilis*), another wilderness-dependent species (Mattson et al. 2001).

Priority research questions on ecological effects include:

- How do non-native species affect ecosystem structure and function within wilderness (e.g., how do non-native species affect natural disturbance regimes, nutrient cycling, or carbon storage)?
- How do non-native species affect the composition of and relationships within biological communities in wilderness?
- How do non-native species in wilderness affect the regional persistence of endangered, threatened, sensitive, and wilderness-dependent species?

SOCIAL VALUES

Wilderness has important existence value for many members of society. People may value the existence of wilderness for its protection of biodiversity, sacred sites, and other irreplaceable resources, or simply because few places remain that are wild and relatively unaltered by people. For example, the majority of Americans oppose oil exploration in the Arctic National Wildlife Refuge because it threatens the region's wildlife and wilderness qualities (Defenders of Wildlife 2003). Wilderness also has subsistence value for some traditional cultures. For instance, many native Alaskans hunt, fish, and trap within wilderness to obtain food and other raw materials critical to their way of life.

Wilderness provides important personal benefits for visitors seeking solitude, inspiration, challenge, and contact with nature. Research is needed to evaluate how non-native species affect human perception and enjoyment of wilderness. High densities of non-native species, especially certain plants, can hinder recreational access or lower an area's aesthetic value. On the other hand, many visitors are unaware of the presence of non-native species, and non-native species can even enhance the wilderness experience for some visitors (e.g., non-native fish stocked in lakes for recreational angling). When weighing management options, wilderness managers must address conflicts between those who favor the removal of non-native species and those who favor their presence (e.g., stocked fish, feral horses and burros) or those who oppose manipulation of the wilderness.

Although some people may object to assigning monetary values to wilderness benefits, economic research demonstrating the financial impacts of non-native species in wilderness may encourage prevention and control efforts. Wilderness benefits that can be quantified monetarily include the provision of critical ecological services to society (e.g., watershed protection, nutrient cycling, carbon storage), tourism revenue to nearby rural communities, and opportunities for recreational use (Loomis and Richardson 2001). Other benefits are more difficult to quantify such as existence value, protection of biodiversity, and providing natural areas for scientific research (Loomis and Richardson 2001). Further research is needed to more fully develop methods that accurately reflect the economic benefits provided by wilderness to society and the impact of non-native species to these benefits.

Priority research questions on social effects include:

- To what extent do non-native species in wilderness affect the existence value (e.g., providing a haven for intact native biological communities) provided by wilderness to society?
- To what extent do non-native species affect subsistence activities (e.g., hunting, food gathering, collecting plant material for traditional medicines) in wilderness?
- To what extent do non-native species affect recreational experiences in wilderness?
- How can conflicts be fairly resolved between people who disagree on whether or not non-native species should be intentionally introduced or allowed to remain in wilderness?
- What are the full range of economic costs and benefits associated with non-native species in wilderness and management efforts directed toward them?

Identifying and evaluating management options and consequences

Under the 1964 Wilderness Act, wilderness managers are expected to maintain natural conditions in wilderness while preserving its “untrammeled” character (i.e., free from human manipulation). Wilderness managers balance these two mandates by choosing the least intrusive action (i.e., the minimum tool) to accomplish management objectives. Determining the minimum tool for non-native species control in wilderness can be especially problematic. Chemical and biological control methods can have unintended, potentially irreversible ecological impacts. However, they also may be the only effective way to combat some non-native species. In addition, managers must often act quickly to prevent non-native species from becoming established in wilderness. Important social issues should also be considered, such as public acceptance of different control methods, public attitudes toward specific non-native species, and, ultimately, the role of humans in wilderness. Managers must weigh the various risks and benefits, both ecological and social, when choosing an appropriate management strategy.

ECOLOGICAL ISSUES

Despite a multitude of information about the immediate ecological effects of different control methods, little is known about the success or failure of specific methods at achieving long-term restoration goals. Published studies tend to focus on whether control methods have reduced populations of the target non-native species, but they seldom monitor the long-term effects on populations of native species. To more efficiently allocate limited resources, managers also need guidance on how to prioritize non-native species for management. Existing and new frameworks need to be further evaluated and/or developed, particularly with respect to wilderness settings. Conducting further research will require time, and managers may need to act immediately using the best available information. Nonetheless, additional information will benefit wilderness managers when making future decisions regarding non-native species management.

Biological control, or biocontrol, agents are considered to be an economical and relatively selective control method. However, these agents are typically other non-native species. Recent research has documented that these non-native agents can have unanticipated effects on native species. For instance, biocontrol agents can negatively impact non-target, native species that are

related to the target species (Louda et al. 1997, Louda and O'Brien 2002). Conversely, native species can adapt and act as predators, herbivores, parasites, or pathogens upon non-native biocontrol agents. In some cases, the biocontrol agents benefit native species that carry serious human disease (Pearson et al. 2000). In other cases, more benign native species benefit from the biocontrol agent (Sheldon and Creed 1995). In these instances, boosting or restoring populations of these native species may be a viable and less intrusive alternative to biocontrol agents. Further research on interactions between native species and biocontrol agents is essential.

Priority research questions on ecological issues affecting the determination and evaluation of management options include:

- What frameworks and decision-support tools are most useful for prioritizing non-native species for management efforts?
- What control techniques serve as the minimum tool to most effectively contain, eradicate, or prevent the establishment of non-native species within wilderness?
- What restoration techniques are most effective at re-establishing native species and ecological processes in wilderness after the removal of non-native species?
- What control and restoration techniques have the least ecological impact within wilderness?
- What are the ecological risks and benefits of alternate control methods in wilderness? How can we better predict the potential negative effects of biological or chemical control on native species prior to their use in wilderness or on adjacent lands?
- Are some native species effective at controlling non-native species in wilderness? In what situations can their populations be augmented or protected to help control non-native species?

SOCIAL ISSUES

Wilderness managers need the cooperation of both wilderness users and society at large to effectively prevent the introduction of non-native species. Accordingly, managers often attempt to educate wilderness users and local communities about the adverse effects of non-native species, as well as ways of preventing their introduction. Communicating desired messages to the public is complicated, however, by several factors. Different people often have different understandings of basic terms such as “weed” and “exotic,” which can greatly influence their perception of the issue (Schwaller 2001). An individual’s receptiveness to a message can also be influenced by his or her attitude toward the agency providing the message. Barriers other than lack of knowledge may also limit compliance with recommended, preventative practices. Harding et al. (2000) offer a useful model for understanding the factors leading to non-compliance with low-impact practices. A diverse array of factors should be considered when designing and assessing the efficacy of alternative educational techniques and messages.

In addition, wilderness managers may need to work collaboratively with surrounding landowners, land agencies, and interested non-governmental organizations (NGOs) to limit the spread of non-native species into wilderness. Managers of surrounding lands, even other resource specialists within the same agency, often have vastly different mandates and goals than the wilderness manager. Additionally, past relationships between nearby communities and landowners with the managing agency can affect the public's willingness to collaboratively address the issue. An improved understanding of these institutional and social barriers, as well as the identification and evaluation of methods to overcome them, should greatly benefit wilderness managers.

Priority research questions on social issues affecting the determination and evaluation of management options include:

- What is the role of humans in actively managing wilderness and how much does it vary for different types of wilderness areas?
- How do managers currently determine their priorities and desired future conditions for non-native species in wilderness? How do these differ among agencies?
- What level of ecological impact is acceptable to the public when dealing with non-native species in wilderness? How much does this level vary for different non-native species and different members of the public?
- What methods and messages can managers use to most effectively educate the public about non-native species impacts and elicit their help in prevention and control strategies? What factors limit the public's acceptance of these messages?
- How can wilderness managers better overcome the institutional and social barriers with surrounding land managers, landowners, and communities to cooperatively manage non-native species?

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