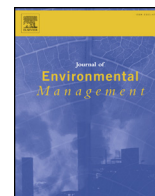




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## Research article

## Public perceptions of mountain lake fisheries management in national parks

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## ABSTRACT

The legacy of fish stocking in mountain lake ecosystems has left behind a challenge for land managers around the globe. In the US and Canada, historically fishless mountain lakes have been stocked with trout for over a century. These non-native trout have cascading ecosystem effects, and can accumulate atmospherically deposited contaminants. While the negative impacts of stocking in these ecosystems have become increasingly apparent, wilderness fishing has garnered cultural value in the angling community. As a result, public lands managers are left with conflicting priorities. National park managers across the western US are actively trying to reconcile the cultural and ecological values of mountain lakes through the development of management plans for mountain lake fisheries. However, visitors' social perceptions, attitudes, and values regarding mountain lake fisheries management have remained unquantified, and thus largely left out of the decision-making process. Our study evaluated the recreation habits, values, and attitudes of national park visitors towards fish stocking and management of mountain lakes of two national parks in the Pacific Northwest. We found that most visitors favor fish removal using a conservation approach, whereby sensitive lakes are restored, while fish populations are maintained in lakes that are more resilient. An important consideration for managers is that many mountain lake anglers consume fish on an annual basis, thus we emphasize the use of outreach and education regarding the accumulation of contaminants in fish tissues. Our findings help elucidate the conflicting views of stakeholders, and we provide recommendations to inform management of mountain lakes fisheries in North America and abroad.

## 1. Introduction

Mountain lakes are perceived by many as pristine and untouched ecosystems. In reality, mountain waterbodies across the world have been under direct and indirect human influence for centuries, resulting in complex management challenges. Mountain lakes are typically oligotrophic waterbodies situated in high forest, subalpine, or alpine mountain ecosystems, with geologic barriers to upstream fish passage and hydrological dependence primarily on atmospheric precipitation and/or glaciers. In the American West, humans have introduced fish to mountain lakes since the turn of the 20th century (Pister, 2001). State and federal fish and wildlife agencies originally began stocking trout into historically fishless mountain lakes to attract support for public lands conservation (Schoenfeld and Hendee, 1978). This practice continued for decades to maintain conservation support, and went largely unquestioned across management and academic communities until recently (Pister, 2001). Beginning in the latter half of the 20th century, scientists began to discover the effects of fish in these lake ecosystems (e.g. Bradford et al., 1998; Eby et al., 2006; Finlay and Vredenburg, 2007; Knapp and Matthews, 2000).

The introduction of fish in mountain lakes has cascading ecological implications. Most notably, fish prey on aquatic invertebrates and amphibians, and outcompete amphibians and alpine-nesting birds for limited food resources, leading to declines in large-bodied zooplankton, macroinvertebrates, and amphibian species (Carlisle and Hawkins, 1998; Epanchin et al., 2010; Finlay and Vredenburg, 2007; Knapp and Matthews, 2000; Sarnelle and Knapp, 2004; Schindler and Parker, 2002). The stocking of non-native trout species in headwater lakes can also have negative downstream effects. In some systems, stocked fish can migrate downstream and compete with native trout species (Adams et al., 2001). In addition to these cascading ecosystem effects, fish stocked in mountain lakes can accumulate relatively high levels of atmospherically-deposited toxins – like polychlorinated biphenyls (PCBs), pesticides, and mercury – which can pose a threat to the health of local wildlife, as well as anglers who consume fish from these lakes (e.g. Landers et al., 2008; Moran et al., 2007).

While the effects of trout introductions on native ecosystems have become increasingly clear, the cultural importance of fish in mountain lakes has made management a complex issue. Many fish-stocked mountain lakes are located in federally protected wilderness areas,

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defined by the Wilderness Act of 1964 as “an area of undeveloped Federal land retaining its primeval character and influence, without permanent improvements ... which is protected and managed so as to preserve its natural conditions...”, and many wilderness areas reside within national park boundaries. Vague policy language in the Wilderness Act has caused conflict and confusion around mountain lake fisheries management, because although the act calls for the preservation of natural and untrammelled land, it also upholds state jurisdiction with respect to fish and wildlife management (Landres et al., 2001). These conflicting passages have led to differences in interpretation of how to implement fisheries management practices in mountain lakes across US federal land management and regulatory agencies (e.g. US Forest Service, Bureau of Land Management, National Parks Service, and US Fish and Wildlife Service) (Landres et al., 2001). Trout stocking is still common in many mountain lakes managed by the US Forest Service and Bureau of Land Management, but the practice is at odds with National Park Service policies in the western US (Landres et al., 2001; Pister, 2001). At present, the National Parks Service has generally terminated mountain lake stocking programs in the western US (Landres et al., 2001).

Although stocking programs have largely ceased in US national parks, debate remains about how to best manage the remaining fisheries in mountain lake ecosystems. Individual national parks approach this problem differently. For example, Mount Rainier National Park (NP) has mainly used manual methods to remove fish (e.g. gill nets), and only experimentally from a few lakes, while other parks in the western US have used, or are considering, chemical removal techniques. North Cascades NP has used the plant-based piscicide rotenone, in conjunction with gill nets, to remove stocked fish from some mountain lakes. However, in 2016, the Washington Department of Fish and Wildlife began re-stocking select mountain lakes in North Cascades NP with species native to downstream waters. This management shift occurred after federal legislation supported by angling groups – the [North Cascades National Park Service Complex Fish Stocking Act of 2014](#) – reinstated stocking in the park. In California's Sierra Nevada Mountains, fish eradication efforts have been kept confidential by management agencies, as to avoid gill net vandalism and re-stocking of lakes by anglers (Halverson, 2011).

The controversies that led to secretive fish removal efforts and the passing of the North Cascades Fish Stocking Act have illustrated the importance of managing mountain lakes as a socioecological system. The current mismatch in stakeholder priorities indicates that there is a conflict between the ecological and cultural value of mountain lakes, and while the opinions of some stakeholders are clear, the attitudes and perceptions of most park visitors toward the practice of fish stocking and management of fisheries are largely unknown. Watson et al. (2015) demonstrated that lack of public input is a common occurrence in wilderness management. However, there is substantial evidence that people can hold strong attitudes and beliefs that shape how they perceive wildlife management (e.g. Fulton et al., 1996; Hall et al., 2010; Manfredo, 2008). In national parks, visitor perspectives are important, as parks strive to maintain management practices that incorporate the needs and desires of visitors for their public lands, as per the [National Parks Omnibus Management Act of 1998](#) (National Parks Service, 2006). In addition, addressing non-native species in mountain lakes is an important aspect of tourism management, which is an integral part of the public lands management (Hall et al., 2010). The importance of considering multidimensional socioecological complexity in land management is also illustrated by Papadimitriou (2012), who uses mathematical modeling approaches as a tool for addressing the complexity of land management. Clearly, there is a need to better assess public attitudes and values around mountain lake fisheries management. In addition, many anglers may not know that atmospherically deposited contaminants can accumulate in mountain lake fish. By understanding recreational habits of visitors and the distribution and drivers of their attitudes toward mountain lake fisheries, management

agencies may be able to create plans that mitigate potential controversy and protect anglers from consuming potentially contaminated fish species.

### 1.1. Research objectives

The goals of our study were to determine: (1) visitors' attitudes toward a spectrum mountain lake fisheries management approaches; (2) how demographics, recreational habits, knowledge, and value-orientations around mountain lakes drive visitor attitudes towards fisheries management approaches; and (3) an approximation of the risk posed to visitors by consuming mountain lake fish, based on reported angling habits. Attitudes are defined as a negative or positive association toward an object (Ajzen 1991), and are driven by value-orientations, i.e., patterns of beliefs within specific domains (Manfredo and Dayer, 2004; Whittaker et al., 2006). Assessing attitudes can be an important part of management decision making. Attitudes are considered components of a cognitive hierarchy that suggests values and attitudes can be used to anticipate human behavior, and are commonly used to understand human-wildlife interactions (Homer and Kahle, 1988; Fulton et al., 1996). According to attitude theory, values are fundamental cognitions that represent ideal end states or desirable ways of behaving, and they form a foundation for attitudes, social norms, and beliefs, which in turn influence behavior (Fulton et al., 1996). Therefore, incorporating visitor attitudes into management plans could help mitigate against future public controversy around mountain lake fisheries management.

We hypothesize the following. First, visitor attitudes will align around two primary management approaches: one that favors maintaining fish in mountain lakes, and one that favors fish eradication. This is based on the theory that the primary wildlife value-orientations are either anthropocentric or biocentric in nature, with underlying drivers of dominance and mutualism, respectively (Manfredo, 2008; Vaske and Donnelly, 1999). In addition, we also expect to see a “middle” group emerge whose attitudes orient around both a concern for ecosystem health and a desire to maintain fisheries resources, as well as a group for whom the issue is not salient and therefore fails to assign an attitude in either direction. These four expected attitude groups can be explained by the finding from Teel and Manfredo (2010) that public lands visitors in the western US typically have attitudes driven by traditionalist (dominance-driven), mutualist (mutualism-driven), pluralist (both mutualism and dominance-driven), and distanced (neither mutualism or dominance-driven) value-orientations. Second, based on the influence of demographics, value-orientations, recreation participation, and perceived ecosystem threats in determining support for wildlife management interventions, we expect these factors to be important predictors of management attitudes (Daigle et al., 2002; Jacobs et al., 2014; Larson et al., 2011; Manfredo, 2008; Scott and Willits, 1994; Teel et al., 2010). In line with Manfredo and Dayer's (2004) explanation of the continuum from “wildlife use” to “wildlife protection”, we expect respondents in favor of stocking to participate in angling or be members of natural-resource groups, and indicate recreation as an important aspect of park waterbodies. Likewise, we expect those in favor of fish eradication to assign ecological importance to park waterbodies, be members of environmental groups, and list climate change as a threat to park ecosystems. Third, we expect the number of people who consume fish from these systems to be small, but those who do consume fish may do so frequently or have the perception that mountain lake fish are pristine.

## 2. Materials and methods

In-person intercept surveys were conducted at campgrounds, trailheads, scenic overlooks, and trail crossings at North Cascades and Mount Rainer NP from July to August 2016. We selected these two parks because the National Parks Service was actively considering

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