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ECOLOGICAL RESTORATION IN WILDERNESS: WHAT THE FISH TO DO?

By

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Professional Paper

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INTRODUCTION

“If anything is endangered in America it is our experience of wild nature—gross contact.” -Jack Turner, *The Abstract Wild*

I'll never forget the first time I had fresh caught trout in the wilderness. I had felt primitive and independent, procuring for myself dinner from the wild. It had never occurred to me that these fish had been on a much greater journey to get here than I had, even though my aching muscles and sore feet suggested otherwise. They had made their way to this remote lake via helicopter, just like so many others before it had for half a century. For the fifty years before that it was on mules and horses. I guess I didn't know enough about fish ecology at the time to wonder that without an outlet for them to swim up, how else would they have gotten there? Another thing I didn't know to contemplate back then was that had I realized how they got there, would it have changed my experience to know that it wasn't truly wild?

Fish have been stocked one way or another in high mountain wilderness lakes in the United States ever since the late 1800's. Many of the introduced fish populations cannot thrive naturally, and require continual stocking efforts to maintain viable populations. Once a supported management action by recreationists and conservationists alike, fish stocking has become more controversial with the increased understanding of the negative impacts to aquatic habitats, as well as with the increase in social values surrounding wilderness. Many agencies have stopped stocking wilderness lakes with non-native fish, and some have begun restoration efforts to remove introduced species and bolster the native ecological community. Some agencies, however, continue to

manage for enhancing recreational fishing opportunities and still stock remote wilderness lakes with non-native fish species today.

As stated in the Wilderness Act of 1964, federal agencies are mandated to preserve wilderness character *and* to manage for public opportunities for recreational, scenic, scientific, educational, conservation, and historical use. Interpretation of how to do that is rarely straightforward. Management decisions often conflict between different values, such as recreation, conservation of native species compositions, or preservation of wild, autonomous nature. In some cases, leaving an area alone to maximize the untrammelled qualities of wilderness can lead to a loss of ecologically important species, whereas restoring it to a former condition in the name of conservation may save species but compromises wildness. In others, choosing to continue manipulating ecosystems for recreation not only has biological consequences, but also infringes on wilderness character. To add to this controversy, state agencies often have different mandates altogether to guide natural resource management, regardless of wilderness designation.

This leads to challenging management decisions involving sets of legal, scientific, and ethical questions in order to find a solution. In many cases there are no clear answers, and any management alternative chosen (including no action) will produce unwanted consequences for *some* aspects of wilderness character or public use. It is important to examine this problem because it will highlight what kinds of questions we need to be asking and answering in order to make informed decisions.

In this paper I evaluate the case study of fish stocking in the Three Sisters Wilderness in central Oregon. The purpose of the paper is to develop a research agenda that will outline what we need to know about the issue in order to choose between

different management alternatives. There is a lot at stake. Our last remaining wild lands are in danger of vanishing under our constant meddling, and our answer to that problem is often further manipulation. There is value in places where man does not interfere. Places where you can escape the heaviness of our handiwork. This is the fundamental reason the Wilderness Act was created, and it has been disregarded over and over again. Unfortunately, countless native species have already vanished in the wake of our poor management decisions, and now we are faced with the ultimate dilemma of whether or not to allow that to continue.

PART ONE: BACKGROUND

History of Wilderness Fish Stocking

Historically, a vast majority of high mountain lakes in the western US were fishless. Due to the geologic processes of glaciation and volcanic eruptions through which these lakes were formed, they either lack outlets or have streams with impassable barriers that prevent fish migration (Knapp et al., 2001; Pister, 2001). Out of approximately 16,000 high mountain lakes found to exist in the western US, most are located within federally designated wilderness areas and national parks, fisheries managers estimate that less than 5% actually contained fish in them prior to the introduction of stocked trout (Bahls, 1992).

Along with settlement and westward expansion in the 1800's came the first trout introductions to these formally fishless waters. These fish initially made their way to the lakes on the pack stock of early sportsmen and backcountry enthusiasts without much in the way of management strategies or environmental considerations. Stocking efforts grew slowly but steadily through the early 20th century and were taken on by various state game agencies that were delegated to manage fish and wildlife resources (Knapp et al., 2001). Due to the isolated nature of the lakes combined with arduous topography, methods of dispersal began to switch from pack animals to aircraft in the 1940's after airplanes and helicopters became readily available (Pister, 2001). Increasing recreation pressures had such an influence on agencies that they relentlessly pursued goals of getting fish to as many lakes as possible.

Aerial stocking and improved hatchery programs allowed fish introductions on such a massive scale that now about 60% of all high mountain lakes contain fish (Bahls, 1992). Most of the 40% that remain fishless are so because they are shallow and small, and it is estimated that less than 5% of the larger, deeper lakes that serve as better trout habitat remain in their historical fishless condition (Bahls, 1992).

Evolving Ecological Awareness

Fish stocking began during a time when a dominant utilitarian view of nature led to conceptualizing the earth as merely a resource for human use, with very little thought to the ecological ramifications of those uses. It happened at a pace so rapid and widespread that it outran scientific inquiry into the effects stocking could have on alpine lakes ecosystems. With increasing environmental awareness and scientific understanding, concern that the presence of non-native fish is threatening to native communities has been growing.

There have been numerous scientific studies that have examined the effects of fish stocking on historically fishless ecosystems, and all have found negative impacts to native species. Scientists are finding that the introduced trout have caused declines in amphibian populations, some of which are now federally listed as threatened or endangered species (Hoffman and Pilliod, 1999; Knapp and Matthews, 2000; Liss et al., 2002; Pilliod and Petersen, 2001; Kiesecker et al., 2001; Dunham et al., 2004). Others have documented declines in other aquatic species as well, including zooplankton and macroinvertebrates, which are vital organisms in all aquatic ecosystems (Parker et al., 2001; Schilling et al., 2009). Studies have also found impacts to the few native fish

populations within watersheds, as many headwater lakes have few barriers to downstream migration (Dunham et al., 2002; Hitt and Frissell, 2000).

Not only have the introduced fish themselves had detrimental impacts to these fragile alpine environments, but heavy recreation use from the rise in popularity of backcountry angling has become more of a problem as well. Increased visitation to these high mountain lakes leads to increased soil erosion and compaction, increases in pathogenic bacteria, introduction of exotic (and potentially noxious) species, vegetation loss, tree damage and loss of woody debris, and wildlife disturbance and displacement (Leung and Marion, 2000).

Legal Ambiguities

The Wilderness Act of 1964 (P.L. 88-577) established the National Wilderness Preservation System (NWPS), which designated federal lands to be managed as wilderness by the United States Forest Service (USFS), Bureau of Land Management (BLM), National Park Service (NPS) and Fish and Wildlife Service (FWS). Followed by over 135 other wilderness bills, there are now more than 109 million acres of designated wilderness administered by these federal agencies (Wilderness.net). A little over 90% of those lands are in the western US, most of which are in the mountains (Landres et al., 2001b). The NPS currently manages the most federally designated wilderness acreage at 40%, with the USFS close behind at 33% (Wilderness.net).

Under Section 4(b), the Wilderness Act states that “each agency administering any area designated as wilderness shall be responsible for preserving the wilderness character of the area and...wilderness areas shall be devoted to the public purposes of

recreational, scenic, scientific, educational, conservation, and historical use.” With the case of fish stocking, these conflicting management objectives contribute to the controversy. While continued management of high lakes fisheries is argued to increase recreational opportunities as well as fall under historical use due to the length of time it has been going on, it has negative impacts on wilderness character and other management objectives such as science and conservation. Because the act doesn’t directly address fish stocking, federal agencies have come up with their own policies, all of which permit fish stocking in wilderness (Landres et al., 2001b).

Controversy stems from different interpretations of the language used to describe wilderness in the Wilderness Act. In Section 2(c), wilderness is defined as “an area where the earth and its community of life are untrammeled by man...an area of undeveloped Federal land retaining its primeval character and influence...protected and managed so as to preserve its natural conditions and which generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable...(PL 88-577)” The meaning of these carefully chosen words has been debated since their inception, but two main values have prevailed: wildness and naturalness.

These two values are often conflicting, as is the case with fish stocking in wilderness areas. Initially, management decisions seem to be pretty straightforward: stop stocking fish in wilderness lakes. Because there are no fish native to 95% of the lakes in the mountain west, this practice ignores the protection of both wildness *and* naturalness mandated by the Wilderness Act. What to do afterwards is much more difficult to decide. Restoration efforts are often needed to repair the damage done to ecosystems

from the introduction of non-native species and return the ecosystem back to its pre-disturbance, “natural” state (Cole and Landres, 1996; Cole, 2000; Landres et al., 2001a). These actions, however, often conflict with wilderness management policies to protect the wildness of the area and to keep it “untrammelled” (Knapp et al., 2001; Landres et al., 2001a; Landres, 2004). It is not possible in many situations to manage for both at the same time, and current laws and policies do not provide explicit guidance for making restoration decisions.

What adds to the legal dispute over the appropriateness of fish stocking in wilderness is the vagueness of the Wilderness Act to spell out the role of state agencies. States often have different priorities concerning fish and wildlife management that conflict with federal wilderness management goals (Pister, 2001). The law states: “Nothing in this Act shall be construed as affecting the jurisdiction or responsibilities of the several States with respect to wildlife and fish in the national forests” (Section 4(d), Special Provisions (8)). While state agencies took this to mean that they still maintained absolute control over all fish and wildlife within their borders given to them by the Tenth Amendment to the Constitution, this is not the case with regards to federally designated land (Jones, 2012). Federal authority has been established through many Supreme Court cases, all of which have declared that under the Property Clause of the Constitution, Congress has plenary power over public lands and any federal legislation applicable to those lands necessarily supersedes state laws (Landres et al., 2001b; Jones, 2012). This includes management of wilderness, and the fish and wildlife within it. Even though this would seem to end the controversy over fish and wildlife management within wilderness, federal agencies are subject to departmental regulations that have reinforced the

responsibility and authority of states to manage fish and wildlife on federal lands (Arthur, 2010; Landres et al., 2001b; Jones, 2012). This has created a joint jurisdiction, causing decision making between state fish and wildlife managers and federal wilderness managers to be all the more difficult.

Conflicting Policies

Fish stocking policy differs between each agency. The NPS and FWS are more concerned with restoration and preservation of native aquatic ecosystems, with special consideration for endangered or extirpated species, whereas the USFS and BLM prioritize meeting wilderness management objectives (Duff, 1995; Landres et al., 2001b). State agencies, often objecting to constraints imposed by wilderness designation, operate under the mandate to provide good recreational opportunities and have had to succumb to greater political pressures from special interests groups than federal agencies (Pister, 2001).

To reconcile these conflicting management interests, federal and state agencies have entered into Memoranda of Understanding (MOU) to provide more formalized guidance, however these still leave room for much discrepancy. In order to facilitate coordination and cooperation between state and federal agencies, the International Association of Fish and Wildlife Agencies (IAFWA), which represents the states, developed a set of wilderness fish guidelines that was jointly agreed upon by the USFS and BLM in 1986 (Duff, 1995; Landres et al., 2001b). While this agreement facilitates mutual understanding between federal and state agencies and gives more specific guidance for fish stocking in wilderness, it still leaves it up to the responsibility of

individuals within each agency to work together and doesn't in itself resolve any conflicts (Landres et al., 2001b).

Recent Controversies

The highest concentration of mountain lakes are found in the Sierra Nevada Range in California, the Cascade Range in Oregon and Washington, and the Rocky Mountains in Colorado, Wyoming, Montana and Idaho (Bahls, 1992). There have been some recent management controversies in these areas that help to highlight the issue of multiagency fisheries management and the impacts on wilderness. Looking at what has been going on in other states can help set the context for the Oregon case study.

California

In the Sierra Nevada, the majority of the mountains are federally managed as national parks and national forests, with a large percentage of that being designated wilderness (Knapp, 1996). Due to NPS priorities placing a greater emphasis on protection of natural ecosystems, fish stocking was mostly discontinued in Sequoia, Kings Canyon, and Yosemite National Parks the 1970's and was completely stopped in 1991 (Knapp, 1996). However, the USFS allows stocking to continue in the surrounding national forest by the California Department of Fish and Game, and almost all these stocked lakes lie within wilderness (Gill and Matthews, 1998). In the mid-1990s, biologists compared the adverse effects of fish stocking on the endangered mountain yellow-legged frog, which has been extirpated from most of its native range. They found that the frogs were present in seven times more lakes in Kings Canyon National Park than in the adjacent John Muir Wilderness, where trout are more abundant (Knapp and

Matthews, 2000). Even though the frog is a federally listed species and federal officials are working on a recovery plan that would include removing fish from some of the lakes, high Sierra sport fishing pressures remain strong on the California Department of Fish and Game to continue stocking.

Montana

In Montana angling pressures are just as strong, maybe more. Recently, Montana Fish, Wildlife, and Parks (MFWP) implemented a controversial recovery program for native westslope cutthroat trout in the Bob Marshall Wilderness Complex. This 1.5 million acre wilderness is home to one of the last remaining populations of genetically pure westslope cutthroat trout, one of the few trout species native to Montana and a highly prized sport fish. They have been either largely displaced from their native range by introduced non-native trout, or have hybridized with them (Marotz, 2004). The Bob Marshall contains the South Fork Flathead watershed, which is a unique stronghold for the westslope because of Hungry Horse Dam near the mouth that has cut it off from invasion from downstream sources. However, because most lakes in the wilderness were historically fishless, they had been stocked with rainbow and Yellowstone cutthroat trout since the 1920s to provide better angling opportunities (Flathead, 2006). By 1983, when a status review for westslope was commissioned by MFWP, it was determined that hybridization was the primary threat to the South Fork populations (Bonneville, 2006).

In 1999, state and federal agencies signed a Memorandum of Understanding and Conservation Agreement for westslope cutthroat trout in Montana, and the MFWP began its development of a conservation plan (Bonneville, 2006). Bonneville Power Administration (BPA) funded the project because of its ownership of Hungry Horse

Dam. Due to the isolation the dam provides, it was proposed that the South Fork Flathead could provide a unique opportunity to remove the threat of hybridization and then potentially keep it that way, protecting the genetic purity of the population (Marotz, 2004). The MFWP plan proposed the removal of all non-native fish from lakes within the drainage using a piscicide, and then restocking them with the native westslope cutthroat trout (Flathead, 2006; Bonneville, 2006). This would be done using either antimycin or rotenone, both of which are chemicals toxic to gill breathing organisms.

Arguably the most notable objection to this project had to be dealt with by the USFS, which was that it would be implemented inside congressionally designated wilderness. The opposition concluded that the actions and methods of the project are forms of trammeling and are in direct violation of the Wilderness Act. These include the use of poison in wilderness lakes and streams, mechanized/motorized transport to and from project sites (including aircraft and helicopter), and the use of motorboats for application (DelHomme, 2006). There were also objections to restocking the lakes, instead arguing for preservation of naturalness by leaving them fishless. Other concerns involved impacts on non-target aquatic species and other wildlife, soils and vegetation, water quality, recreation, and socioeconomics (Bonneville, 2006; Flathead, 2006).

In this case both federal and state agencies agreed, and MFWP and the USFS determined in the Record of Decision (ROD) that for a complete and effective removal, these methods would be the minimum necessary to reach the project objectives (Flathead, 2006; Bonneville, 2006). An interesting point illustrates the value of recreation and the power of a multimillion-dollar angling industry: among the alternatives listed in the ROD, none of them included not restocking the lakes after removal to their historical

condition. The agencies claim that catching fish in wilderness lakes has become an important part of visitor experience, and they have a responsibility to provide that. They also fear that people will stock fish illegally if they don't (Marotz, 2004).

Washington

There was a surprising turn of events in the North Cascades National Park Complex (NOCA) recently. A bill was passed on July 25, 2014 that reversed the decision by the National Park Service in 2009 to ban fish stocking practices in the 91 historically fishless lakes within the park complex (HR 1158, 2014). Sponsored by Representative Doc Hastings (R-WA), Chair of the Parks and Resources Committee of the US House of Representatives, the "North Cascades National Park Service Complex Fish Stocking Act" directs the Secretary of the Interior to authorize fish stocking in up to 42 lakes in the park complex, including the Stephen Mather Wilderness.

Fish stocking in the NOCA has long been a contentious issue. The park complex was originally created in 1968, and was followed by the Washington Park Wilderness Act of 1988, which established 93% of the North Cascades Complex as Stephen Mather Wilderness (USDI, 2008). Influenced by the Leopold Report, which informed park managers to return ecosystems back to their original condition before the arrival of Euro-Americans, the NPS had been phasing out fish stocking practices since the 1970s in order to restore and maintain native communities (Leopold et al., 1963; Louter, 2003). Also charged with managing in accordance with the Wilderness Act of 1964, the designation of the Stephen Mather prompted the NPS to examine fish stocking practices with even more scrutiny, which further solidified the ban on stocking historically fishless waters. The moratorium on fish stocking was highly contested not only by the state of

Washington Department of Fish and Wildlife, but also private sport fishing groups that had been assisting the state with stocking these lakes since the 1930s (Louter, 2003).

Both the state and private parties felt that because the fish-stocking program had been their responsibility well before the park was established, the NPS was imposing on their authority to maintain recreational fishing opportunities.

In 1985 both agencies signed a Memorandum of Understanding (MOU) that mandated ecological research on the effects of fish stocking in the park complex; the park was subsequently sued by an environmental organization, the North Cascades Conservation Council (NCCC), because they were to allow fish stocking in the interim (Louter, 2003). In 1991 a consent decree was established between the NCCC and NPS, requiring the agency to review the fish-stocking program through an environmental impact statement (EIS). After over a decade of research by scientists at Oregon State University and the USGS Biological Resources Division showed impairment of native aquatic ecosystems (Liss et al., 2002), the NPS initiated the Final Mountain Lakes Fishery Management Plan/EIS that evaluated those impacts as well as potential restoration opportunities (USDI, 2008). The EIS completed in 2008, and the subsequent Record of Decision outlined management alternatives, including the chosen and environmentally preferred Alternative D, in which all 91 lakes would be fishless. At the time, 62 of the 91 lakes had fish so after discontinued stocking efforts, a combination of natural die-off and active removal would restore the lakes to their historical fishless condition (USDI, 2008). The highly controversial 2014 legislation effectively reversed this decision, and mandated the continued stocking of lakes within the NOCA.

Management Dilemmas

Controversies surrounding this issue often lead to litigation. In both California and Washington there have been numerous lawsuits involving the ecological impacts of non-native fish stocking, as well as impacts on wilderness character. It is only a matter of time before this pattern continues in Oregon, which is why it is important for state and federal agencies to evaluate different management alternatives to address this issue before it gets to that point. However, these situations create the difficult task for wilderness managers to optimize trade-offs between conflicting wilderness values and uses.

Conflicts arise between different goals of managing for the preservation of lands in their “natural conditions,” “untrammelled by man” and for “the public purposes of recreational, scenic, scientific, educational, conservation, and historical use” (PL 88-577, Sec 4b). These create dilemmas that wilderness managers must resolve (Cole, 1996). In the following case of fish stocking in the Oregon Cascades, the dilemma is threefold: stop stocking fish to preserve the Three Sisters Wilderness as untrammelled, manipulate the wilderness by removing fish to restore natural conditions and protect threatened species, or continue to stock fish for recreational purposes. Unfortunately, there are many barriers that make these management decisions challenging. Political conflicts, social and ethical disputes, and vague and insufficient legal instructions only add to the complicated nature of these situations. On top of that, our understanding of the ecological consequences of our actions is constantly evolving and there are still many scientific uncertainties that remain. It is critical that we evaluate what questions we need to be answering in order to make informed management decisions that aim to resolve this issue.

PART TWO: OREGON CASE STUDY



Introduction

This case study is intended to illustrate the evaluation of ecological restoration in designated wilderness. Currently, there is no official proposal for the restoration of historically fishless lakes in the Three Sisters Wilderness, or any other wilderness in Oregon. This case study serves as an example of what a restoration project of this nature would entail. The management alternatives addressed in this case study are based on similar restoration projects implemented in the North Cascades, Sierra Nevada, and Montana.

History of Three Sisters Wilderness

The Three Sisters Wilderness area lies within the central Oregon Cascades, and is the second largest wilderness in the state of Oregon (Wilderness.net). Straddling the Cascade Range, the area is managed by the Deschutes National Forest to the east and the Willamette National Forest to the west. It also spans four ranger districts: Bend/Fort Rock, McKenzie River, Middle Fork, and Sisters. It was originally designated by the USFS as a Primitive Area in 1937, with just over 191,000 acres. The passage of the Wilderness Act of 1964 gave more permanent protection to the area, and increased the designation to 196,708 acres. Additions were made with the passage of the Endangered American Wilderness Act in 1978 and the Oregon Wilderness Act of 1984, bringing the total to the currently designated 283,630 acres (Wilderness.net). The area is bordered by the Mount Washington Wilderness to the north (54,452 acres) and the Waldo Lake Wilderness to the south (36,868 acres).

The wilderness area encompasses the high volcanic peaks of the South Sister (elevation 10,358 feet), the Middle Sister (elevation 10,047 feet), and the North Sister (elevation 10,085 feet). Topographical relief ranges more than 8,000 feet from around 2,000 feet above sea level near the McKenzie River Ranger Station to the summit of the South Sister at 10,358 feet. The relatively recent volcanic activity over the past few thousand years has shaped the landscape, and the area abounds with cinder cones, lava fields, and lava-dammed lakes. It also contains some of the best examples of the effects of glaciation in the Pacific Northwest, and alpine meadows, waterfalls, glaciers and glacial lakes are abundant. Collier Glacier, the largest ice field left in the state of Oregon, rests between the slopes of the North and Middle Sister (Wilderness.net).

The Cascade Range acts as a barrier for moisture that originates over the Pacific, creating a rain shadow effect that results in different climate zones on either side of the mountain range. The western slopes are warmer and wetter temperate marine, while the eastern slopes are semi-arid continental and experience cooler and drier conditions. Due to this contrast in climate, the forested regions on the western slopes are dominated by Douglas fir, while the eastern side is predominantly ponderosa pine. At the lower elevations, other trees commonly found include western hemlock, grand fir, noble fir, Pacific silver fir, western redcedar, and western white pine. Higher elevation forests include mountain hemlock, subalpine fir, Engelmann spruce, lodgepole pine, and whitebark pine. The alpine terrain above tree line consists mainly of barren lava flows and moist to dry alpine meadows, with dominant flora consisting of lupine, paintbrush, heather, arnica, larkspur, sunflowers, and columbine. The wilderness is abundant with wildlife, commonly including elk, black-tailed deer, mule deer, black bear, bobcat,

cougar, coyote, mink, marten, weasel, mountain beaver, pika, snowshoe hare, grouse, amphibians, and various species of trout (ODFW).

The Three Sisters Wilderness is extremely popular for recreation. Mountaineering and angling opportunities abound, and every year the South Sister and Green Lakes area alone gets anywhere between 15,000 and 20,000 visitors. That number is based on only those permits actually filled out (Urness, 2013). Recreation pressures have motivated and perpetuated controversial management practices that provide for such opportunities. Fish stocking of alpine lakes for backcountry angling is one of those practices.

The Ecological Restoration Issue

Fish stocking has occurred throughout most of the Cascade lakes since the early 1900's, first via pack stock and later with the use of airplanes and helicopters. Currently, ODFW stocks over 450 high mountain lakes every other year (ODFW, 2015). Most fish stocked are either brook or rainbow trout, but other species including cutthroat, brown, golden, and lake trout have been stocked as well. Due to their volcanic and glacial formation, the majority of the lakes were historically fishless. Approximately only 20 to 30 lakes on the western slopes of the Cascades had outlets that connected them to lower river systems and actually contained native cutthroat trout populations prior to stocking efforts (Hutchison, 2011).

Since almost all of the lakes within the Cascade Mountains historically contained no fish, these aquatic ecosystems have been dramatically altered following their introduction. Studies have shown that the presence of non-native trout has decreased

amphibian and macroinvertebrate populations through predation (Cushman and Pearl, 2007; Dunham et al., 2004; Hoffman and Pilliod, 1999; Knapp, 1996; Knapp and Matthews, 2000; Liss et al., 2002; Parker et al., 2001; Pilliod and Petersen 2000, 2001; Reid, 2005; Schilling et al., 2009), as well as the through the introduction of pathogens such as fungi (Blaustein et al., 1994; Cushman and Pearl, 2007; Kiesecker et al., 2001).

In the Cascades, the amphibian species of most concern is the Oregon spotted frog (*Rana pretiosa*), which was listed as threatened under the Endangered Species Act in August of 2014 (USDI, 2014). This species has been extirpated from nearly 90% of its former range, and more than two-thirds of populations known to still exist are located within the Cascade Range in central Oregon (Cushman and Pearl, 2007; Pearl et al., 2009). Threats listed include not only habitat loss, but also interactions with non-native fish involving predation and disease.

The Oregon Department of Fish and Wildlife (ODFW) avoids stocking lakes known to contain populations of Oregon spotted frog, but continues to stock fish in areas of suspected spotted frog dispersal habitat (Cross, pers. comm., 2015). Even though the ODFW has stopped stocking lakes that have Oregon spotted frog in them, there are naturalized populations of brook trout in most of the lakes. Furthermore, ODFW stocks lakes that are known to have overland flow in the spring that connects them to lakes with Oregon spotted frog populations. A conservation assessment for the Oregon spotted frog calls for the need to evaluate or discontinue fish-stocking practices and consider ecological restoration efforts (Cushman and Pearl, 2007). This would include maintaining sites that lack nonnative fish in that condition, as well as removing fish from

sites known to contain Oregon spotted frog and those that are connected to Oregon spotted frog sites by overland flow.

Many of the lakes currently stocked in the Cascade Range lie within federally designated wilderness. More than 80 lakes are stocked every other year with brook and rainbow trout in the Three Sisters Wilderness (ODFW, 2015). Restoration actions to remove these fish would be quite intensive, and often require the use of piscicides and mechanized equipment to be successful. Restoration projects therefore degrade the untrammeled qualities of wilderness character, even if only temporarily, and potentially act as a slippery slope to other management actions otherwise restricted by the Wilderness Act. Another option would be to quit stocking altogether and let the wilderness reclaim its wildness, but the established populations of fish would continue to have an impact on the natural qualities of aquatic ecosystems and the declining Oregon spotted frog.

Law and Policy Criteria

The Three Sisters Wilderness is managed in accordance with the following laws, policies, and management directives.

Laws

Wilderness Act of 1964 (PL 88-577)

The Wilderness Act of 1964 originally designated 196,708 acres of the central Oregon Cascades as federally protected wilderness. Section 4(b) of the Wilderness Act states “each agency administering any area designated as wilderness shall be responsible for preserving the wilderness character of the area and shall so administer such area for

such other purposes for which it may have been established as also to preserve its wilderness character.” Section 2(c) defines wilderness as “an area where the earth and its community of life are untrammelled by man...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, with the imprint of man's work substantially unnoticeable...” This Act also created the Mount Washington Wilderness to the north.

Endangered Species Act (PL 93-205)

This law was created in 1973 to protect threatened and endangered native species and the habitats upon which they depend, with the ultimate goal of restoring a species to ecological health so it no longer needs the protection of the ESA. It is administered by the Fish and Wildlife Service (FWS) and National Marine Fisheries Service (NMFS). Section 7 of this Act states that “Federal agencies shall, in consultation with and with the assistance of the Secretary, utilize their authorities in furtherance of the purposes of this Act by carrying out programs for the conservation of endangered species and threatened species listed pursuant to section 4 of this Act.” The Oregon spotted frog is listed as threatened.

Endangered American Wilderness Act of 1978 (PL 95-237)

Section 3(e) of this Act designated an additional 45,400 acres as “French Pete Creek and Other Proposed Additions, Three Sisters Wilderness.” It states in Section 1(a)(3) that “these and other undeveloped national forest lands exhibiting wilderness values are immediately threatened by pressures of a growing and more mobile population, large-scale industrial and economic growth, and development and uses inconsistent with the protection, maintenance, restoration, and enhancement of their

wilderness character..." The French Pete Creek valley on the Willamette National Forest had been removed from earlier protection due to logging potential, but local opposition arose in order to protect the old growth forest. Congress declared it to be in the national interest to protect this valley as wilderness, as well as other endangered areas across the western US, as furtherance of the Wilderness Act of 1964.

Oregon Wilderness Act of 1984 (PL 98-328)

The passage of this Act designated a total of 859,600 acres across the state of Oregon as wilderness within the National Wilderness Preservation System. This Act declares these lands to be managed in accordance with the provisions of the Wilderness Act of 1964. Section 3 added 38,100 acres to the Three Sisters Wilderness, as well as 6,400 acres to the Mount Washington Wilderness. It also created the 39,200-acre Waldo Lake Wilderness to the south.

Policies

USDA Forest Service National Headquarters FSM 2300 – Recreation, Wilderness, and Related Resource Management, Chapter 2320 – Wilderness Management (USDA, 2006).
2320.3. – Wilderness Management (FSM 2300)

1. Where there are alternatives among management decisions, wilderness values shall dominate over all other considerations except where limited by the Wilderness Act, subsequent legislation, or regulations.
2. Manage the use of other resources in wilderness in a manner compatible with wilderness resource management objectives.
3. In wildernesses where the establishing legislation permits resource uses and activities that are nonconforming exceptions to the definition of wilderness as described

in the Wilderness Act, manage these nonconforming uses and activities in such a manner as to minimize their effect on the wilderness resource.

4. Cease uses and activities not essential to the administration, protection, or management of wilderness for wilderness purposes or not provided for in the establishing legislation.

2323.32 Management of Wildlife and Fish (FSM 2300)

1. Recognize that States have jurisdiction and responsibilities for the protection and management of wildlife and fish populations in wilderness. Cooperate and work closely with State wildlife and fish authorities in all aspects of wildlife and fish management. Base any Forest Service recommendation to State wildlife and fish agencies on the need for protection and maintenance of the wilderness resource. Recognize wilderness protection needs and identify any needed requirements in coordination efforts and in cooperative agreements with State agencies.

2. Wildlife and fish management programs shall be consistent with wilderness values.

3. Discourage measures for direct control (other than normal harvest) of wildlife and fish populations.

4. Manage wilderness to protect known populations of federally listed threatened or endangered species where necessary for their perpetuation and aid in their recovery in areas of previous habitation. When alternative areas outside of wilderness offer equal or better protection, take actions to recover threatened or endangered species outside of wilderness areas first.

5. Apply the "Policies and Guidelines for Fish and Wildlife Management in Wilderness and Primitive Areas," developed jointly by the Forest Service, Bureau of Land Management, and the International Association of Fish and Wildlife Agencies in a practical, reasonable, and uniform manner in all National Forest wilderness units. Use the guidelines as a foundation for or as addendums to State or individual wilderness cooperative agreements.

Site-specific Planning Documents

Willamette National Forest Land and Resource Management Plan (1990)

Deschutes National Forest Land and Resource Management Plan (1990)

Special Provisions

Fish Stocking

There is no provision in the Wilderness Act that explicitly allows for fish stocking. Still, it does recognize that the Act does not change the authority for the management of fish and wildlife already delegated to the states. This did not, however, delegate the responsibility to preserve wilderness character to the states. Since both state and federal agencies maintain jurisdiction over the management of fish resources yet operate under different mandates, conflicts ensued. A set of guidelines was developed jointly by the USFS, BLM, and the International Association of Fish and Wildlife Agencies (which represented the states) in 1986 in order to facilitate coordination between the agencies. This was amended most recently in 2006 (Duff, 1995; Landres et al., 2001b). The Memoranda of Understanding (MOU) entered into by the USFS and ODFW asserted that both agencies mutually agree to utilize these policies and guidelines

as the foundation for management of fish and wildlife within National Forest Wilderness in Oregon (USDA, 1990).

2323.34c - Stocking Policy (FSM 2300)

1. Do not stock exotic species of fish in wilderness. The order of preference for stocking fish species is:
 - a. Federally listed threatened or endangered, indigenous species.
 - b. Indigenous species.
 - c. Threatened or endangered native species if species is likely to survive and spawn successfully.
 - d. Native species if species is likely to survive and spawn successfully.
2. Stock barren waters only after determining that the scientific and research values of such barren waters will not be eliminated from a wilderness and documenting the desirability of such action in the forest plan.
3. Consider on a case-by-case basis presently unstocked waters that at one time supported an indigenous fish population and that could provide suitable habitat for an indigenous species with unusual wilderness appeal.

ODFW Mission

The mission of the Oregon Department of Fish and Wildlife (ODFW) is to protect and enhance Oregon's fish and wildlife and their habitats for use and enjoyment by present and future generations. The Department is charged by statute ORS 506.036 to protect and propagate fish in the state. This includes direct responsibility for regulating harvest of fish, protection of fish, enhancement of fish populations through habitat improvement, and the rearing and release of fish into public waters.

Fish Removal

There is no provision in the Wilderness Act that explicitly allows for fish removal either. It does, however, enforce the responsibility of federal agencies to manage for the protection of wilderness character and natural conditions. Policies related to fish removal are addressed in the AFWA as well.

2323.35a - Manipulation of Wildlife Habitat (FSM 2300)

The objective of all projects must be to perpetuate the wilderness resource; projects must be necessary to sustain a primary value of a given wilderness or to perpetuate a federally listed threatened or endangered species. To qualify for approval by the Chief, habitat manipulation projects must satisfy the following criteria:

1. The condition needing change is a result of abnormal human influence.
2. The project can be accomplished with assurance that there will be no serious or lasting damage to wilderness values.
3. There is reasonable assurance that the project will accomplish the desired objectives.

Test major projects through a pilot study. The pilot study should take place in a comparable area outside of wilderness if possible.

Give first priority to locating habitat improvement projects outside wilderness for the benefit of wildlife that spend only part of the year in wilderness.

2323.34f - Chemical Treatment (FSM 2300)

Chemical treatment may be used to prepare waters for reestablishment of indigenous, threatened or endangered, or native species, or to correct undesirable conditions caused by human influence. The Regional Forester approves all proposed uses of chemicals in wilderness (FSM 2150).

Restoration Objectives and Mandate to Preserve Wilderness Character

Current laws and policies do not offer explicit guidelines for ecological restoration in wilderness, but require managers to evaluate these actions while preserving wilderness character. This is agreed upon by National Wilderness Preservation Managers as five fundamental qualities: (1) untrammeled; (2) undeveloped; (3) natural; (4) solitude or primitive and unconfined recreation, and, (5) other features of value (Arthur, 2010). It is clear that fish stocking in the Cascades degrades some of these qualities and continuation of these practices should be reevaluated. What isn't clear is whether or not the actions required to restore these mountain lakes to a more natural state are worth the impacts to other qualities of wilderness character.

Considering the adverse impacts of non-native fish on other native aquatic species, the only way to prevent further degradation would be to remove reproducing trout from historically fishless lakes. In order to protect and recover the Oregon spotted frog, lakes with known populations would need to have fish removed and areas known to connect with those lakes through overland flow would also need to be treated. These restoration actions, while bolstering the natural qualities of the Three Sisters Wilderness, would degrade the untrammeled quality of wilderness character.

Restoration Treatments and Affected Environment

Restoration treatments to remove fish involve three main methods: natural, mechanical, and chemical (Cross, pers. comm. 2015). Naturally removing fish from lakes involves ceasing the stocking of lakes known to contain only populations of non-reproducing fish and letting them die out. Since many lakes in the Cascades now contain

self-sustaining populations of trout, these methods would only be effective in those lakes that do not. Mechanical methods include capturing fish with seines, gill nets, and electrofishing. These methods have not shown to be very effective, especially in large, densely populated lakes. Chemical treatments to eradicate fish involve the use of piscicides, usually either antimycin or rotenone. Antimycin has shown to be effective in small streams, shallow ponds and alpine lakes, whereas rotenone has been reported to be more effective in large rivers and deep lakes (Vinson et al., 2010). Piscicide application is done using motorboats in larger bodies of water, and often requires aircraft for transport of materials and personnel. Treatments used for fish removal would depend on the site-specifics of each lake. Lake location, depth, size, ecological attributes and chemistry are all critical components to determine appropriate restoration and monitoring strategies.

Monitoring

Extensive monitoring for several years following restoration treatments is needed to evaluate effectiveness, and should be implemented using the minimum requirements necessary to accomplish goals. Monitoring plans would be determined based on treatment methods utilized, resources needed and available, and ecological sensitivity of each location. Every effort to reduce impacts to wilderness character should be exercised. Adaptive management strategies would provide a useful tool for evaluating monitoring results and adjusting future management actions to achieve the desired objective.

Possible Management Alternatives

Alternative A: No Action

Current practices would continue; therefore, most lakes in the Three Sisters Wilderness would continue to have fish.

Alternative B: Restoration of pre-stocking condition

Use mechanical and chemical treatments to remove fish from all lakes not known to historically contain fish, restoring them to their fishless condition.

Alternative C: Partial restoration of Oregon spotted frog habitat

Stop stocking lakes that are critical and known habitat for the Oregon spotted frog, and use mechanical methods to remove fish. Continue stocking fish in lakes that are not known habitat, and are not connected by overland flow. Transport Oregon spotted frog to areas of suitable habitat.

Alternative D: Untrammelled

Stop stocking all wilderness lakes and let the wilderness be untrammelled, not taking further action to regain historically fishless conditions.

Stakeholder Values

Environmental groups have voiced concern over current fish stocking practices that have adversely impacted native biota, as well as proposed restoration actions to reverse those impacts. One such organization is Trout Unlimited. Their position is clearly stated in their North American Salmonid Policy: “Trout Unlimited advocates that naturally fishless waters of natural diversity value not be stocked with non-native species at present or in the future. Further, where a body of scientific evidence shows that

stocking in historically non-salmonid waters adversely affects native biodiversity, such stocking should cease (Trout Unlimited, 1997).” They go on to state that while they are in support of native biodiversity and realize the importance of historically fishless ecosystems, they are not necessarily advocating for the removal of established populations of non-native fish. They conclude that it may not be ecologically feasible or practicable in some situations, and that risks to entire aquatic communities posed by aggressive restoration efforts should be thoroughly evaluated (Trout Unlimited, 1997).

Another organization that has expressed concern is Wilderness Watch. Their policy on fish stocking in wilderness is as follows: “Fish stocking that is intended to modify wilderness for recreational purposes, stocking with non-indigenous species, or fish stocking in lakes or streams historically and naturally devoid of fish is unacceptable (Wilderness Watch, 2015).” Even though Wilderness Watch is generally in support of efforts to end fish stocking and remove non-native fish from historically fishless ecosystems, the organization has voiced serious concern and opposition when those efforts include the use of piscicides, motorized equipment and transport (Wilderness Watch, 2015). They highly value the untrammeled qualities of wilderness, and don’t feel that those practices meet the minimum tool requirement mandated by wilderness stewardship guidelines.

While not necessarily against fish stocking in wilderness, the perspectives and values of the USFS differ from what ODFW is currently doing. With input from fish biologists and a mandate to preserve wilderness character, the agency has shown a preference to reduce stocking programs in wilderness areas (Cross, 2015, pers. comm.). They are faced with increasing challenges of managing recreation and preservation of

these highly popular areas, and see the need to prioritize limiting human impairment to all aspects of wilderness character.

ODFW is heavily influenced by pressures to provide recreational fishing opportunities on public lands across the state, and not necessarily to protect other qualities of wilderness. One-third of the agency's annual budget comes from the sale of hunting and fishing licenses, and other funding comes from the federal government through sales of hunting and fishing equipment (ODFW, 2015). Recreational fishing is a big industry in the state of Oregon. Based on data from the US Fish and Wildlife Service, anglers in Oregon spent over \$680 million in 2011 alone on fishing-related expenses (USDI, 2011b). When combined with economic activity generated by indirect expenses, this produced an economic output of over \$1.2 billion and supported over 11,000 jobs (Southwick Associates, 2013). Since the early 1900's the state of Oregon has responded to the public desires of stocking fish in remote wilderness lakes, and those desires remain strong today.

Individual stakeholder groups include various fly-fishing clubs, the Oregon Chapter of Backcountry Hunters and Anglers, guides, and other businesses that benefit from backcountry angling opportunities. Because almost all lakes within the Three Sisters Wilderness were historically fishless, to restore these natural ecosystems would mean a huge impact on backcountry angling in central Oregon.

Effects Analysis

This section highlights the potential effects of the different management alternatives on all five qualities of wilderness character, including positive, negative, and

neutral. Alternatives B and C both require fish removal, so are evaluated together. Both short term and long term effects are addressed.

Untrammeled

Alternative A- No Action (Fish stocking): Continued stocking of historically fishless lakes highly impacts the untrammeled qualities of the Three Sisters Wilderness, as it is a continuous form of ecological manipulation and intentional control over species composition for recreational purposes. These effects are both short term and long term.

Alternatives B and C- Restoration (Fish Removal): Actions required to remove fish from high mountain lakes will degrade this quality. Restoration treatments using mechanical or chemical means intentionally manipulate the earth and its community of life that currently exist in the Three Sisters Wilderness, and therefore are a form of trammeling. These effects would ideally be short term, because if objectives are achieved and fish are successfully removed then further manipulation would not be needed and evidence of human control could cease to exist.

Alternative D- Untrammeled (No Stocking): Discontinuing fish stocking would have a positive effect on this quality, both short and long term. Fish stocking is an intentional manipulation, which is a trammeling action.

Undeveloped

Alternative A- No Action (Fish stocking): Current practices involve the use of aircraft for widespread aerial stocking. Impacts to the undeveloped quality are both short term and long term, because most lakes are stocked at two-year intervals to maintain non-reproducing fish populations.

Alternatives B and C- Restoration (Fish Removal): Restoration treatments involving the transport of supplies and personnel to the site using aircraft, as well as use of motorized equipment to apply piscicides would degrade the undeveloped quality of wilderness in the short term. These effects would only be apparent during the treatment and monitoring process, and would not be long term.

Alternative D- Untrammelled (No stocking): Discontinuing stocking would have a positive effect on this quality, both short and long term. No more equipment would be used for fish stocking.

Natural

Alternative A- No Action (Fish stocking): Continuing to introduce fish into ecosystems that they are not native severely impacts the natural qualities by dramatically altering those habitats for other native aquatic species.

Alternatives B and C- Restoration (Fish Removal): Restoration of historically fishless lakes would improve the natural qualities of the Three Sisters Wilderness because it would be achieving the natural conditions that were present prior to stocking.

Alternative D- Untrammelled (No stocking): By not taking further action to restore fishless conditions, this would have a negative effect on the natural quality of wilderness in lakes where there are self-sustaining populations on non-native fish. In lakes where populations of introduced fish would die off, this quality would be improved.

Solitude or primitive and unconfined recreation

Alternative A- No Action (Fish stocking): Stocking of high lakes increases recreational opportunities for backcountry anglers and is seen as a positive outcome for those in support of that type of recreation. However, this draws more use into these areas

and subsequent crowding greatly decreases opportunities for solitude for all visitors. This leads federal agencies to develop restrictions in order to protect over-used areas, and recreation becomes somewhat confined.

Alternatives B and C- Restoration (Fish Removal): Restoration actions would temporarily degrade opportunities for solitude with the use of aircraft and motorized equipment in remote alpine lake environments, and would also close the areas to recreation for the duration of treatments. These adverse impacts on visitor experience would only be short term while the restoration project is being implemented, however projects of this nature take many years to accomplish their objectives. Long-term impacts on recreation would include the loss of high lakes fishing opportunities, but would not affect other types of primitive recreation.

Alternative D- Untrammelled (No stocking): Discontinuing stocking would decrease fishing opportunities, which could have both positive and negative effects on this quality depending on what types of recreation are valued. By removing some of the attraction to these lakes, it would positively impact solitude and may lessen the need for agencies to implement restrictions.

Other features of value

Alternative A- No Action (Fish stocking): Carrying on this practice would continue to benefit those in agreement that fishing is part of a unique experience in Oregon wilderness. It does, however, degrade this quality for those that do not share this view and believe the Three Sisters Wilderness provides a unique opportunity for restoration of historic ecological communities.

Alternatives B and C- Restoration (Fish Removal): There is a lot of public support in Oregon for remote fishing opportunities, and many see this as being a highly valuable part of their wilderness experience that they cannot find elsewhere. Removing fish from these lakes would degrade this quality for those visitors. Also, ODFW utilizes volunteers to aid in stocking efforts by hiking in fish to remote lakes using backpacks, and many people involved in this program have voiced that their involvement in this tradition is part of a unique historical and cultural connection to the wilderness.

Alternative D- Untrammled (No stocking): This alternative would have similar effects to Alternatives B and C, but would have a potentially lower impact on this quality because of self-sustaining populations of trout that are already established in the wilderness. These fish would likely remain and remote angling could continue, albeit on a much smaller scale.

Risks and Uncertainties

The biggest risks imposed by restoration projects of this nature are through the use of piscicides, either antimycin or rotenone. Both of these belong to a class of chemicals that disrupt cellular respiration, and are considered Organic Pesticides (Vinson et al., 2010). Even though the use of these piscicides has been in practice for more than 70 years to manage fish populations, the long term effects of these chemicals on aquatic ecosystems is still not yet well known (Vinson et al., 2010). While the effects on fish have been well documented, the impacts to other aquatic invertebrates and amphibians have been less researched and therefore remain uncertain. Studies have shown that both rotenone and antimycin are toxic to larval amphibians and aquatic macroinvertebrates

that use gills for respiration (Billman et al., 2011; Darby et al., 2004; Vinson et al., 2010). Even less is known about the adverse downstream effects of potassium permanganate, which is a neutralizing agent applied after treatment that is also potentially toxic to aquatic organisms.

These impacts are of critical concern because of the objective to conserve the Oregon spotted frog, as well as the importance of macroinvertebrates to the food chain in aquatic ecosystems. Research has shown antimycin to be less harmful to macroinvertebrates (Darby et al., 2004; Hamilton et al., 2009) and amphibians (Turner et al., 2007) than rotenone, most likely due to the lower concentrations needed for typical piscicidal applications. However, rotenone is often used because it has been proven to be more effective in larger bodies of water, as well as more commercially available (Vinson et al., 2010).

Other uncertainties surround the success of the restoration treatments in actually removing all fish from the lakes. Such aggressive and invasive measures that directly violate the Wilderness Act and degrade wilderness character would need to be decided upon with relatively high certainty that they would work in order to be worth the trade-offs. Even if they are successful, agencies worry that lakes would be illegally stocked after projects are completed and would render the efforts useless and a waste of resources (Johnson et al., 2009).

Potential Outcomes

Removal of non-native fish from mountain lakes in other states has been shown to yield good results for the restoration of native aquatic ecosystems. Long-toed

salamanders have recolonized lakes in the Selway Bitterroot Wilderness in Montana following the extinction of introduced trout that died off after stocking practices were stopped in 1984 (Funk and Dunlap, 1999). Lakes in the John Muir Wilderness in the Sierra Nevada have experienced a rapid recovery of the mountain yellow-legged frog after non-native trout were removed (Vredenburg, 2004; Knapp et al., 2007). Post-treatment monitoring of lakes in the North Cascades National Park Complex has also shown a dramatic rise in amphibian populations in the absence of non-native fish (USDI, 2011a). These cases provide evidence that restoration of native aquatic species can be achieved through the removal of introduced fish.

Even though there is significant potential for the improvement of the natural qualities of wilderness through restoration, there is also the potential for the untrammeled qualities to be significantly degraded for quite some time. Interventions of this magnitude require years of invasive management techniques that would negatively impact those values associated with the humility and restraint required to let a wilderness be wild. On the other hand if fish stocking practices are stopped, and no further actions for manipulation are taken, there is potential for a deepened respect of nature's autonomy, reduced unintended consequences, and a chance to observe evolutionary change and learn from our past mistakes (Landres, 2010).

PART THREE: RESEARCH AGENDA

The purpose of this research agenda is to outline questions to address in order for managers to make informed decisions on this issue. The Three Sisters Wilderness case study generates four management alternatives, but we don't fully know what the consequences of each alternative are to be able to choose between them. Here are the most important research questions that still need to be answered to evaluate these alternatives.

Ecological

How well do these restoration treatments actually work? What are the potential outcomes for each alternative? How many lakes would return to a fishless condition on their own from discontinued stocking, and how many would continue to have self-sustaining populations of fish?

In order to answer these questions, testing of restoration actions needs to be carried out. This would ideally be done outside wilderness first, in order to evaluate the results before implementing anything inside wilderness boundaries. One lake would be the control, where stocking activities would be stopped. One lake would be treated mechanically, while another would be treated with piscicides. This would provide an opportunity to evaluate the effectiveness and consequences of each method. Another lake would continue to be stocked with fish.

Another line of research could involve evaluating what the characteristics are of lakes that would simply return to a fishless condition on their own after stocking practices are stopped, and what the characteristics are of those that would continue to have

naturally reproducing populations. Also, it is important to evaluate characteristics of lakes where chemical treatments would be effective, as well as those lakes where mechanical treatments have good potential for success.

How will the use of piscicides impact other aquatic species of concern besides fish, both short term and long term?

More research is needed on the impacts to other aquatic species of concern from the use of piscicides, such as macroinvertebrates and amphibians (Vinson et al, 2010). These species are critical for the health of aquatic ecosystems, and restoration outcomes would be dramatically hindered if there were long-term declines to local populations of these species. Use of piscicides has shown to be harmful to these organisms and could potentially lead to further degradation of these lake environments (Billman et al., 2011; Darby et al., 2004; Vinson et al., 2010), so further evaluation of these effects is needed before their use is considered.

Is this action necessary to protect the Oregon spotted frog, or are there enough opportunities outside wilderness that will allow viable populations to remain? How many frogs need to survive in order to stabilize the population? To what degree does this species need to have fish removed in order for that to happen?

Evidence of Oregon spotted frog occupancy within its range has been inconclusive due to a lack of adequate surveying, mostly due to access or resource limitations (USDI, 2013). There is, however, proposed critical habitat both inside and outside wilderness that would allow for the recovery of the Oregon spotted frog if conservation measures are implemented. Because the ESA listing of the Oregon spotted frog is so recent and data about its existence is lacking, further research needs to be done

in critical habitat areas to see which restoration actions would be sufficient for species recovery. Research is needed to find out how many frogs in each area need to survive to stabilize local populations, and how many different local populations are needed to stabilize the entire population of the species. It is critical to look at the degree to which these local populations need to be protected from predation by non-native fish in order for adequate survival.

The US Fish and Wildlife Service (USFWS) has identified Oregon spotted frog critical habitat areas (USDI, 2013). Critical habitat adjacent to the Three Sisters Wilderness include lakes, marshes, and riverine habitats within the Upper Deschutes River sub-basin unit, the Little Deschutes River sub-basin unit, the McKenzie River sub-basin unit, and the Middle Fork Willamette River sub-basin unit. Another important inquiry would be to determine which lakes that are within these critical habitat units have the characteristics of those that would return to a former fishless condition without further manipulation, and which are lakes that would respond to chemical or mechanical treatments. If enough of these lakes exist outside wilderness that would provide sufficient protection for species recovery, then no further action may be necessary within wilderness.

How is recreation impacting the environment? How much of that is related to fishing?

Studies have shown dramatic impacts to fragile alpine environments in the Three Sisters Wilderness from heavy recreational use (Leung and Marion, 2000; Monz et al., 2013). In some of these areas restrictions have already been established to reduce these impacts. What still needs to be determined is the amount of increased usage directly

related to angling opportunities, and which lakes have been impacted the most. These studies should look at factors like the number of daily visitors to each lake and whether or not they came there because of fish, the frequency of stocking, ease of accessibility and/or the existence of previous user trails, proximity to trailheads, and other attractions such as scenery or lake features favorable for fly-fishing techniques. These results could then be compared with assessments of ecological impacts at each lake and correlations could be made as to whether or not these impacts are related to angling. This could help managers determine which lakes are getting used the most, and evaluate whether or not stocking is contributing to overuse.

Legal

*Do the alternatives actually adhere to the requirements of the Wilderness Act?
What about the Endangered Species Act? Are current practices even legal?*

Wilderness managers need to better examine current management practices by taking a stringent look at the intent of these federal laws and evaluate whether or not we have actually been upholding the objectives set forth by these laws. Managers also need to reexamine the exceptions made to allow actions that were in place before the wilderness was established. If these actions are shown to cause harm, and the purpose of wilderness designation is to protect these areas from harm for the future, then these actions should be deemed illegal and be discontinued.

*Will chosen alternatives set a legal precedent for future management decisions?
If so, what are the ramifications?*

Constant bending of the rules can create a dangerous slippery slope that will only further degrade wilderness character if it continues to allow trammeling actions to occur for one reason or another. This possibility should be evaluated before allowing implementation of restoration actions or continued fish stocking in wilderness, and preventative measures need to be identified.

What are the political barriers?

The legislation that took place recently in the North Cascades provides a good opportunity to identify what political motives are present, and how they can influence decision-making. Political lobby groups and their potential leverage need to be identified in Oregon. This also begs the question of who really has the power in these decisions, the USFS or ODFW?

Ethical

Does it really make sense to kill one species to save another? What are we really trying to achieve, and more importantly, why? What are the implications of too much interference?

These questions need to be taken seriously. Too often management decisions are made using a utilitarian point of view: how can we benefit the most people? In the case of wilderness fish stocking it seems that past decisions have shown that this comes down to the anglers. What we need to do is address these ethical questions by incorporating the values of all entities involved, including the fish and all other species that would be affected. Some people feel strongly that we don't continue to use these fish as pawns, providing recreational entertainment while contributing to the demise of other aquatic

species. Others don't think it is right to poison something just because we have now determined it doesn't belong there. Still others have argued that humans need to adopt more humility when it comes to the environment, and that we need to stop "playing god" with the natural world. Research should be done by seeking out public comments on these management alternatives to get a better understanding of the ethical issues within each alternative.

Social

What values are most important to users of the Three Sisters Wilderness? What is the general spectrum of wilderness knowledge among those users?

Social science research to answer these questions would need to be done by interviewing wilderness visitors. This would allow managers to be better informed about how decisions will affect the experience of those who visit the Three Sisters Wilderness. Questions should get at not only what people value about their wilderness experience but also why. Also, gauging wilderness knowledge among users can be useful to determine how many people are aware of concepts like wilderness character, what impacts those qualities, and that there are laws in place to protect those qualities. Many people may not know that the activities they value have negative consequences for the environment or the experiences of other people. Often, given adequate information, can provide an opportunity for people to reevaluate their perspectives on wilderness preservation and recreation.

Is there public support for these alternatives? Which ones?

This is an important research question. Each management alternative will have a different group of people that support it, and significant backlash can happen when agencies ignore the magnitude of political sway some of these groups can have. A critical component to consider when researching public support is for agencies to maintain transparency, and to be very clear about the objectives of each alternative being proposed. Again, public comments are considered for answering these questions.

CONCLUSION

Wilderness management decisions are about as clear as mud. One thing that is certain is that the issue of fish stocking in wilderness is highly complicated and often perplexing, and very rarely clearly guided by legislation. Wilderness managers are faced with the dilemma of minimizing trade-offs and maximizing benefits, all the while succumbing to the objectives of state agencies and somehow preserving wilderness character for future generations at the same time. Heightened ecological awareness has led some to believe that restoration is the answer to fixing problems that we have created. But is it the right one?

The risks and uncertainties in a project like this are high. If the restoration treatments do not work as intended, then the wilderness has been trampled for no reason. There could be more severe consequences for non-target species than predicted, and the Oregon spotted frog could be harmed further instead of assisted to recovery. Many people claim backcountry angling is a valuable part of their wilderness experience. Although the wilderness is not to be used for commercial purposes, loss of angling opportunities could have cascading effects on local livelihoods and could even result in reduced support for wilderness preservation. Uncertainties over jurisdiction between state and federal agencies remain ambiguous, and somehow have resulted in maintaining the status quo even though the impacts to wilderness character are highly apparent.

I think that to truly resolve this issue, we need to get back to the roots of the Wilderness Act itself. Situations today remind me of the game of telephone, where much of what we interpret 50 years later to be “allowed” by the Wilderness Act does not even come close to what was originally intended. Federal agencies are constantly authorizing

activities that are wildly inconsistent with the purpose and language of the Act (Jones, 2015). The word “untrammeled” was chosen for a reason, and the author Zahniser himself was adamantly reminding us that we are to be “guardians, not gardeners” (Zahniser, 1963). The use of “untrammeled” has been misinterpreted to mean undisturbed, but this is more of a description of ecological condition. Synonymous with unconfined, unfettered, and unrestrained, “untrammeled” actually refers to freedom from human control rather than a lack of human influence (Cole, 2000). Interpretations of the meaning of “natural” vary greatly, and are often ambiguous and conflicting (Aplet and Cole, 2010). While historically fishless ecosystems may seem to be the “natural” conditions that humans have altered, to many people it is just an arbitrary point in the past and doesn’t address humans as a part of nature.

The goals of preserving biodiversity *and* allowing for ecosystems to be unfettered are challenging, and where landscapes are left alone, change is inevitable (Aplet and Cole, 2010). One thing is clear to me in the case of stocking fish in wilderness lakes: just stop doing it. We might never be able to achieve historical conditions, and with climate change this is an even bigger reality. But when we know that an action is causing harm to native ecosystems, *and* is a form of trammeling that violates the very foundation of wilderness preservation, we ought to stop. Just because things get “grandfathered in” doesn’t mean they are right. The question of allowing further ecological manipulation is more difficult, and is one that needs more research in order to fully evaluate. With the case in Oregon, it seems that it is not worth the amount of risk involved without a better understanding of the consequences. Is a species of frog really worth all that trouble, when climate change just might finish them off anyways? At least the preservation of

humility, restraint, and wildness is within our power to save, even if it means a change in species composition. If we lose our ability to refrain from meddling with certain places, who knows what other cascading effects that will have not only on the earth, but on our relationship with it as well.

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