NORTH CASCADES NATIONAL PARK

Stephen Mather Wilderness

Restoring mountain lakes to a naturally fishless state through the use of piscicides and mechanical treatment methods.

Case Study of Ecological Restoration in Wilderness

2008

NATIONAL PARK SERVICE

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This case study is part of a collaborative partnership between the Aldo Leopold Wilderness Research Institute and The Wilderness Society to describe ecological restoration actions that have been implemented within the National Wilderness Preservation System. The specific case studies were selected to represent a mix of wilderness agencies, geographic regions, restoration issues and complexities. The case studies were written by staff at the Leopold Institute, in consultation with wilderness managers.


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SUPPORTING GRAPHICS

Acronyms
EIS-Environmental Impact Statement
MRA-Minimum Requirements Analysis
NEPA-National Environmental Policy Act
NOCA-North Cascades National Park Service Complex
MOU-Memorandum of Understanding
WDFW-Washington Department of Fish and Wildlife

Brief Timeline of Events

- Late 1800's, stocking of some mountain lakes for food and recreational purposes
- 1933 State of Washington assumes responsibility for stocking mountain lakes
- 1968 establishment of NOCA, establishing legislation does not address fisheries management
- 1970's and 1980's, NOCA attempts to phase out stocking, but abandoned due to objections by WDFW
- 1986, former NPS Director William Mott issues a policy variance authorizing stocking to continue only in lakes that had been previously stocked and directed park staff to conduct ecological monitoring to provide an informed basis for fishery management
- 1987 William Horn, Assistant Secretary of the Interior, negotiated an agreement between NPS and WDFW to authorize fish stocking in certain lakes, and have the monitoring research support the development of a publicly reviewed recreational fishery management plan (vi, background). This was formalized by the NPS and WDFW in 1988 and known as the "Supplemental Agreement"
- 1988 NCCC sues the NPS over various management plans for Lake Chelan NRA. The lawsuit was settled in a 1991 Consent Decree and a stipulation says that the NPS would conduct a NEPA review of fish stocking of naturally fish-free lakes.
- 1988 WA Wilderness Act establishes the Stephen Mather Wilderness
- 2008 NOCA publishes the Mountain Lakes Fishery Plan and EIS
- 2008-2013 fish removal begins in 7 lakes
- 2014 President Obama signs the "North Cascades Fish Stocking Act", which allows for the stocking of up to 42 lakes

INTRODUCTION

The passage of the Wilderness Act by Congress in 1964, followed by President Lyndon Johnson signing the Act into law, marked a new era in protected area designation and public land management for the United States. Under the newly established National Wilderness Preservation System (NWPS), wilderness was, "recognized as an area where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain. An area of wilderness is further defined to mean in this Act an area of undeveloped Federal land retaining its primeval character and influence, without permanent improvements or human habitation, which is protected and managed so as to preserve its natural conditions…" (PL 88-577).

Fifty years after the passage of the Wilderness Act, a combination of major ecological stressors-including invasive species and climate change-are creating new and unprecedented challenges for wilderness managers. Today, ecological restoration has become one of the most important, ethically complex, and potentially litigious wilderness stewardship issues in the history of the Wilderness Act. More specifically, the legal mandate to preserve the natural quality of wilderness character is leading managers to consider increasingly intrusive management interventions in place of historically minimal management. The dynamics and uncertainties of this management shift call into question traditional planning approaches, such as the use of historic conditions to define management targets; and require the incorporation of diverse legal, scientific and ethical considerations into management planning.

The four agencies that manage wilderness—the Department of the Interior Bureau of Land Management (BLM), U.S. Fish and Wildlife Service (USFWS), National Park Service (NPS), and the Department of Agriculture U.S. Forest Service (USFS)—receive hundreds of proposals to implement ecological restoration and other types of intervention actions within the NWPS every year now, including an increasing number of proposals generated by climate adaptation objectives. Ecological interventions that are currently proposed and implemented within wilderness include:

- Actions that sustain, restore, or manage vegetation (e.g., chemical and mechanical removal of invasive plants, planting trees, spreading seed and fertilizer);
- Actions that sustain or restore fish and wildlife, or manage insects and disease (e.g., biological control agents, fish stocking, animal removal, fish barriers, water guzzlers, introducing animals);
- Actions that manage soil and water issues (e.g., diverting water for irrigation, mine site reclamation, spreading lime to buffer acid deposition); and,
- Actions that manage fire (e.g., suppressing naturally-caused fire, mechanical fuels reduction treatments, prescribed fire).

Current law and policies do not provide an explicit, decision-making framework for wilderness stewardship in the face of these new threats, but require wilderness managers to evaluate the effects of proposed restoration actions while simultaneously preserving wilderness character. Based on the legal definition of wilderness, National Wilderness Preservation Managers agree on five fundamental qualities of wilderness character: (1) Untrammeled; (2) Undeveloped; (3) Natural; (4) Solitude or primitive and unconfined recreation, and, (5) Other features of value. As defined by the Wilderness Act, wilderness lands are intended to be protected in their "natural condition" (i.e. species, patterns, and processes that evolved in the area) and "untrammeled by man" (i.e. free from intentional modern human control and manipulation). Balancing the natural and untrammeled qualities of wilderness character is a persistent wilderness stewardship challenge that may force a decision tradeoff. In addition, the accumulation of seemingly small-scale decisions and management actions, as well as taking no action at all, has the potential to change wilderness character over time.

In this document, we present a case study of an ecological restoration action that has been implemented within a designated wilderness in an attempt to preserve its wilderness character. The intent of these case studies is to provide detailed information about the tradeoffs involved in making decisions that simultaneously affect the natural and untrammeled qualities of wilderness, characterize similarities in management activities across projects, learn more about the basis for proposed ecological restoration, and understand the impacts of restoration projects that have been implemented.

FRAMING THE ECOLOGICAL PROBLEM

History of the Stephen Mather Wilderness

North Cascades National Park Service Complex (NOCA), located in northwestern Washington, was established in 1968 with strong support from local organizations concerned about resource extraction in the region. NOCA consists of three units: 505,000-acre North Cascades National Park; 117,600-acre Ross Lake National Recreation Area; and 62,902 Lake Chelan National Recreation Area. The Stephen Mather Wilderness was designated in 1988 through the Washington Wilderness Act, which cited several wilderness characteristics such as rugged mountains, over three hundred glaciers, and numerous cascades. The Stephen Mather Wilderness covers 94% of NOCA, and consists of 634,614 acres across the three units. In 1989 a Wilderness Stewardship Plan was developed and is still in use today, which focuses on visitor use management and utilizes the limits of acceptable change model (LAC).

Ecological Setting (NPS 2015)

NOCA is located in the North Cascade physiographic province in northwestern Washington. It is bounded on the west, south, and east by 4.7 million acres of National Forest lands, of which 1.9 million acres are designated wilderness. NOCA's northern boundary is the international boundary with the Canadian province of British Columbia. NOCA spans the Cascade crest, placing within its boundary two major biogeographic zones: temperate marine and semi-arid continental. The climatic and biotic diversity are further increased by a transitional zone, roughly the lower elevations of the Ross Lake drainage. The third zone is created by an orographic divide west of the crest. Vegetal and climatic characteristics within this zone are intermediate between the mild, wet conditions typical of the west side and the semi-arid conditions typical of the east side of NOCA.

The Park is characterized by deep, forested valleys between high, glaciated mountain peaks. The local topographic relief is 8,800 feet, with the lowest point being 400 feet along the Skagit River and the highest elevations occurring on several mountain peaks over 9,000 ft. The Park contains 316 glaciers, more than all of the other national parks within the conterminous states combined. From the glaciers, permanent snowfields, and 561 lakes flow approximately 1,945 miles of rivers and streams. Several major rivers are present in the Park Complex including the Chilliwack River, the Nooksack River, the Skagit River, the Baker River, and the Stehekin River.

The abundance of water and the wide variation in landforms, soil types, elevation, slope, and aspect create many types of habitat that support a diversity of flora and fauna. There are as many as 75 mammal, 200 bird, 26 species of native fish, 11 reptile and amphibian, and roughly 1,630 vascular plant species within the Park. All the high lakes in the Complex were devoid of fish due to natural barriers to fish migration in their outlet streams.

In a broad sense, the vegetation of the Park Complex is typical of the vegetation found throughout mountainous areas of the Pacific Northwest. Douglas-fir (*Pseudotsuga menziesii*), Western Hemlock (*Tsuga heterophylla*), and Pacific Silver Fir (*Abies amabilis*) dominate the lower and montane slopes of the west side of the Complex. The east side is drier and dominated by dry Douglas-fir and Ponderosa Pine (*Pinus ponderosa*) forests. Riparian zones throughout the Complex are dominated by deciduous trees including alder (*Alnus* spp.), cottonwood (*Populus* spp.), and willow (*Salix* spp.). The upper elevations of the Park Complex are primarily Subalpine Fir (*Abies lasiocarpa*) and Mountain Hemlock (*Tsuga mertensiana*) forests. The eastern mountain slopes have those 9 components as well as Subalpine Larch (*Larix lyallii*), Whitebark Pine (*Pinus albicaulis*), and Engelmann Spruce (*Picea engelmannii*). Above forestline, moist to dry subalpine meadows dominate. Roughly 230 species of non-native plants are found within the Complex, including Diffuse (*Acosta diffusa*) and Spotted Knapweed (*Centaurea stoebe*), Rush Skeletonweed (*Chondrilla juncea*), St. John's Wort (*Hypericum perforatum*), Scotch Broom (*Cytisus scoparius*), Japanese Knotweed (*Fallopia japonicus*), Cheatgrass (*Bromus tectorum*), Common Mullein (*Verbascum thapsus*), and Herb Robert (*Geranium robertianum*).

Ecological Restoration Issue

As mentioned above, all of the mountain lakes in NOCA were naturally fishless and these lake ecosystems evolved with amphibians and insects as the dominant predators. However, early non-indigenous settlers began stocking the alpine lakes in NOCA with fish in the late 1800s, and in 1933 the State of Washington began formal stocking initiatives to provide for a recreational fishery in the region (NPS 2008). When NOCA was established in 1968 there were no specific written provisions regarding the continued stocking, even though stocking is contrary to National Park Service policy (NPS 2006). Starting in the 1970s stocking became contentious because the WDFW wanted to continue stocking mountain lakes, while NOCA disagreed due to concerns about the impacts on native amphibian and invertebrate communities. In 1985, a memorandum of understanding (MOU) between NOCA and WDFW was established mandating ecological monitoring of the lakes to gauge the effect of stocking, and in the interim period stocking would continue. A lawsuit filed by the North Cascades Conservation Council (NCCC), an organization instrumental to park and wilderness establishment, required NOCA to complete a National Environmental Policy Act (NEPA) review of the fish stocking practice.

In July of 2008, NOCA completed the Mountain Lakes Fishery Management Plan and Environmental Impact Statement (MLFMP/EIS) to satisfy the mandated NEPA review. The MLFMP provides future management direction for 91 of the park's 245 mountain lakes cited in the plan which are large enough to support fish (90 lakes are in wilderness), all of which were historically fishless and had been stocked in the past or where observations or harvest of fish have been documented. Based on aquatic monitoring conducted over the past 20 years it was determined that the highest degree of biological integrity[1] was found in lakes that had never been stocked, and lakes with the lowest degree of biological integrity contained reproducing populations of nonnative trout or char that had achieved high densities and exceeded the carrying capacity of the lake (NPS 2008). Trout are opportunistic feeders, and will eat a

[1] For the purposes of the MLFMP, biological integrity is defined as, "the capability of supporting and maintaining a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitat of the region" (NPS 2008, p. 494).

variety of prey in mountain lakes, including amphibians, insects, and plankton. For example, monitoring results indicated that amphibian populations in lakes with high densities of reproducing fish were suppressed and that in some situations the non-native fish were interbreeding with native fish populations downstream, thereby changing the unique genetics of native fish populations.

The effects of fish stocking in naturally fishless lakes in wilderness are associated with a host of ecological and social impacts effecting wilderness character. For example, Knapp (2000, 2001) concludes that fish introductions dramatically alter native vertebrate and invertebrate communities often resulting in the extirpation of native fishes, amphibians, zooplankton and benthic macroinvertebrates. Consequently, studies indicate that following fish removal, full recovery of an ecosystem structure and function may not occur. Landres et al (2001) noted the effects of fish stocking on wildness and the social values of wilderness. They concluded that the intrusive and artificial action of stocking fish to create recreational opportunities compromises wildness through the actions of manipulation. In addition, the use of mechanization involved with stocking via planes and helicopters violates the spirit of the Wilderness Act and its prohibition against motorized vehicles, even if they do not land. Aerial stocking degrades primitive recreation experiences by disrupting the solitude and quiet that most visitors seek (Cordell et al 1998).

The Wilderness Act mandates that agencies managing wilderness must preserve the wilderness character, including the natural and untrammeled qualities. In the Stephen Mather Wilderness, the presence of non-native fish species degrades the natural quality of wilderness character and constitutes an anthropogenic threat to native species. NOCA hopes that by removing the stocked fish, the biological integrity of the mountain lakes will improve, thereby improving the natural quality of wilderness. Thus the short-term trammeling actions of fish removal and monitoring were deemed acceptable, in exchange for the long-term benefits of restoring the lake to a fishless state. As this case study is analyzing the effects of wilderness management actions on wilderness character, we will assess the impacts of fish stocking as well as the removal of non-native fish as management actions.

RESTORATION PROPOSAL & IMPLEMENTATION

In this section we review the legal and political framework guiding the restoration action, along with restoration objectives, ecological criteria, monitoring, management alternatives, values and ethics, and an effects analysis.

Law and Policy
See appendix 1 for specific laws and policies effecting this restoration proposal.

Valid Existing Rights and Special Provisions

Valid Existing Rights
There is disagreement between the Washington Department of Fish and Wildlife and the National Park Service over the degree of jurisdictional authority to stock waters in the national park portion of North Cascades Complex. For the purpose of this analysis, we defer to the NPS interpretation of the enabling legislation and legislative history for the North Cascades Complex, which does not consider WDFW fish stocking a valid existing right (NPS 2008).

Special provisions in legislation (the 1964 Wilderness Act or subsequent laws), that allows for this project or activity

Fish Removal: There is no provision in the enabling legislation, the Wilderness Act, or the Washington Park Wilderness Act that explicitly allows for fish removal. However, as an administrative unit of the National Park System, the North Cascades National Park Service Complex is governed by the National Park Service Organic Act (39 Stat. 535, codified at 16 U.S.C. sections 1-4), which prohibits the NPS from allowing impairment of park resources or values. Thus, the NPS would have the authority to remove fish from wilderness lakes if their presence has the potential to impair park resources or values (NPS 2008).

Fish Stocking: There is no provision in the enabling legislation, the Wilderness Act, or the Washington Park Wilderness Act that explicitly allows for fish stocking. However, as of July 2014, the North Cascades National Park Service Complex Fish Stocking Act mandates the continued stocking of no more than 42 of the lakes that had been stocked historically, using fish native to the slope where the lake is located.

Restoration Objectives and Mandate to Preserve Wilderness Character

Results from studies conducted in the North Cascades and other mountain ranges have concluded that non-native fish, especially reproducing high density populations of non-native fish, alter food webs and degrade native amphibian communities (Knapp et al 2001; Knapp & Matthews 2000; Liss et al 2002). The MLFMP states, "Given the well-documented impacts of non-native, reproducing populations of fish on native organisms, the NPS believes it is imperative to remove, wherever feasible, populations of reproducing trout from naturally fishless lakes" (NPS 2008, p. 324). The MLFMP concludes that if reproducing populations of non-native fish remained in the lakes, over time there would be major adverse impacts to native biota. To achieve the goal of restoring the ecosystem to a more natural state, NOCA would need to potentially remove high-density reproducing populations of non-native fish in up to 38 of the mountain lakes in the Stephen Mather Wilderness. Moreover, NOCA states that restoring the lakes to a naturally fishless state must be accomplished in order to administer the area as wilderness, in spite of the short-term impacts to the wilderness experience that will occur during fish removal (NPS 2008, p. 324). The intent of the park's action is to return the mountain lakes to their natural state and remove a human-caused threat; however these actions constitute a degradation of the untrammeled quality of wilderness character.

Implementing the park's preferred alternative (Alternative B in the EIS) requires 49 out of the 91 lakes in the study area to be fishless. Currently 29 of the 49 lakes are currently fishless, so NOCA will remove fish populations from 20 lakes and manage them as fishless. An additional 18 lakes with high-density reproducing fish populations will also have fish removed. In a strategized adaptive management plan, the reproducing populations of fish will be removed, and ecological monitoring will determine if the lake is capable of supporting low densities of non-reproducing fish for recreational fishing opportunities in the future. Stocking the lakes requires an act of Congress, and if this had not been received, the park would default to implementing Alternative D in the EIS (the environmentally preferred alternative), which requires fish to be removed from all mountain lakes with no stocking in the future. From 2008 to 2014, NOCA has been implementing Alternative D, removing fish from mountain lakes beginning with

the most ecologically degraded. However, in July of 2014, the North Cascades National Park Service Complex Fish Stocking Act of 2014 was signed into federal law. This law, sponsored by Representative Hastings of Washington State with support from pro-angling constituents, directs the Secretary of the Interior to authorize the stocking of fish in not more than 42 lakes, as outlined in Alternative B of the EIS. Today, NOCA staff have removed fish from nine lakes, leaving 29 lakes that need to be evaluated as candidates for fish removal.

Restoration Treatment and Affected Environment

As per NPS policy, an integrated pest management system (IPM) was used to identify the best available strategy for addressing the non-native fish in each unique lake system. The range of options for removing high densities of non-native fish includes mechanical and chemical methods. Mechanical methods involve gillnetting, electrofishing and trapping; chemical methods include the application of antimycin and rotenone (antimycin was used in two lakes until it was no longer commercially available, and rotenone, CFT legumine, was used in larger lakes beginning in 2013[2]). Only 10 lakes are less than five acres in size and are therefore suitable for gillnetting (NPS 2008). Natural methods including the ending of stocking, followed by natural die-off of non-reproducing fish, can be used for lakes with low-densities of fish.

A three-phased approach is then implemented: the first year is the assessment phase; the second year is the treatment phase; and, the third year is the assessment and follow-up phase (NPS 2008). During the assessment phase, biological, chemical and physical data are collected to understand species abundance and diversity, and the potential sensitivity of native aquatic species. Lake depth, size and volume are also measured and mapped to calculate the piscicide dose needed to kill the fish while minimizing the effect on non-target organisms. To apply piscicides, the chemical is diluted with lake water and then poured into the prop wash of an electric trolling motor mounted to an inflatable boat. A combination of live trapping, caged fish bioassays, and gillnetting are used to determine treatment progress and effectiveness. Piscicide treatments include mitigation practices to neutralize the chemicals at outlet streams and to avoid unnecessary effects to aquatic communities downstream of the treatment area. The third phase, conducted for five years following the application of rotenone includes monitoring the response of zooplankton, aquatic insect and amphibian communities.

Monitoring

The MLFMP establishes a specific restoration plan for adaptive resource management based on the existing condition of each mountain lake (see appendix 2). A lake selected for mechanical or chemical fish removal is treated and then monitored annually to examine the effects of the treatment. For both mechanical and chemical fish removal actions, helicopters are used to transport material, supplies, and personnel. Annual aquatic monitoring data is analyzed and used to adjust future strategies based on the presence and density of fish detected in the mountain lakes. Pre- and post-treatment monitoring is

[2] The switch of piscicides was due to the lack of commercially available antimycin. A complete analysis was completed for switching piscicides from antimycin to rotenone (NPS 2013).

conducted to inform the treatment plan and to assess restoration efficacy, and also contributes to the landscape scale NPS Vital Signs Monitoring. NOCA is in the North Coast and Cascades Network and submits data to this regional network that assesses overall ecosystem health on a national level.

Management Alternatives

Various management alternatives were assessed in the EIS that differ primarily in the number of lakes that would contain fish. Common to each alternative is the practice of adaptive management, outreach and education, partnerships and lake treatment methods.

Management Alternatives Discussed

Alternative A: No Action

This alternative maintains current conditions; therefore 62 lakes would have fish.

Alternative B: Preferred Alternative

This is the alternative that was preferred during the time the plan was written, however it required an Act of Congress to approve stocking in up to 42 lakes where certain ecological conditions exist. With this alternative, a total of 42 lakes may be stocked with fish and fish-removal would commence for 38 mountain lakes. From July of 2014 forward, NOCA will be implementing this alternative.

Alternative C: Proposed Adaptive Management Alternative

For this alternative, 11 lakes may have fish. This alternative was not chosen because it did not accomplish park objectives to restore lakes to a naturally fishless state.

Alternative D: Environmentally Preferred Alternative

This alternative requires that all 91 lakes be fishless. When the MLFMP went into effect, the North Cascades National Park Service Complex Fish Stocking Act of 2014 had not been in place yet, so from 2008 to 2014, NOCA was implementing this alternative. When the Act passed in July of 2014, the park reverted to Alternative B, which allowed some lakes to be stocked with fish depending on their ecological composition.

Stakeholder Values

Four hundred seventy-five comments were extracted from 91 correspondences were during the public scoping process for this restoration action. Twenty-four comments were in support of the environmentally preferred alternative (alternative D) which mandated that all fish be removed from mountain lakes. Fifteen comments were in support of the preferred alternative, which mandated the removal of reproducing fish populations and the potential for up to 42 lakes to be stocked in the future. An additional 30 comments were received in support of fish stocking, while 6 comments expressed opposition over potential fish stocking. Overall, there was strong support to remove high densities of reproducing fish from the mountain lakes; however, the issue of stocking the lakes after fish removal was contentious.

Around 1,000 anglers visit the mountain lakes in NOCA each year for recreational fishing opportunities. During public scoping of the MLFMP and EIS, local anglers voiced their support in favor of continued fish stocking to preserve their recreational fishing opportunities. The Washington Trailblazers, Washington Hi-Lakers, and WDFW opposed the fish stocking prohibition because they valued the opportunity to fish

in the high mountain lakes of the North Cascades (NPS 2008). Some organizations, such as the Washington Trail Blazers and the Hi-Lakers, support the stocking initiative to preserve some lakes as unique fishing arenas in concert with removing high densities of reproducing nonnative fish. Several public comments focused on the historic precedent of stocking, and a few even cited personal trips to stock the lakes before the park was established. There was also a strong appeal to the cultural element of fishing that sharply contrasted with the wilderness manager's need to remove human-caused threats.

Some visitors who valued natural ecosystems without the presence of non-native species expressed concern about why NOCA was pursuing legislative action to allow stocking when all other laws guiding NOCA management mandate the protection of biodiversity and natural conditions (NPS 2008). Twenty-six comments were received regarding the impacts of the proposals on wilderness, and 32 separate comments addressed the Minimum Requirements Analysis for proposed actions in wilderness. Outside groups such as Wilderness Watch opposed the use of rotenone to remove the non-native fish because they saw it as a degradation of the untrammeled quality of wilderness. However, most groups supported the removal of reproducing populations of non-native fish populations using gillnets or chemical methods.

Park employees were divided on this issue, and to date the most vocal groups against the restoration action were a select group of NOCA employees. These employees opposed the action because they believed the application of piscicides posed an unacceptable risk to the ecosystem and degraded the untrammeled quality of wilderness character in the Stephen Mather Wilderness, despite an improvement to the natural quality of wilderness character in the future. Some staff expressed opposition because of the experimental nature of applying chemicals into a remote wilderness. Others opposed the action primarily because of the extent to which mechanized equipment would be used during fish removal operations.

Park employees in favor of the fishery restoration action value a natural landscape that is free from evidence of past human control, despite potential adverse impacts that may occur during fish removal. They value a resilient ecosystem that is composed of native species and natural processes and for them this outweighs any potential risk during fish removal. In their eyes, they have the resources to remove a human-caused threat to the ecosystem, and they have support from agency policy to proceed. For some people the degradation of the untrammeled quality was justified due to the ecological benefits of removing non-native fish. The Minimum Requirements Analysis for the MLFMP states, "Though recreational fishing is widely regarded as an important and traditional use of wilderness, the role of stocking to create and maintain an artificial fishing opportunity in naturally fishless mountain lakes is viewed by many as an artificial manipulation of both wildness and naturalness. These views are informed by a wide body of scientific research into the impacts of fish stocking, including findings specific to lakes in the North Cascades Complex" (NPS 2008, p. viii).

Effects Analyses

In the following effects analysis section, we observe how the restoration action affected the five qualities of wilderness character. The five qualities are derived from the legal definition of wilderness cited in The Wilderness Act of 1964, and are used as a management tool for agencies to comply with law

and policy, and improve wilderness stewardship by assessing the implications of management actions[4]. Implementing the MLFMP, and complying with the North Cascades National Park Service Complex Fish Stocking Act of 2014, will have significant effects on the five wilderness characteristics.

Untrammeled:

- *Removing Fish*
    - Removing fish using chemicals and gillnetting constitutes a trammeling of wilderness despite the length of time associated with fish removal actions. However, the duration of fish removal actions does determine the degree to which wilderness character is impacted. Fish removal actions began in 2009 and the time needed to fully implement the MLFMP is unknown because of variability in annual funding and resources. To date, NOCA staff have been removing fish from one to four lakes annually.

Natural

- *Removing fish*
    - Using mechanical, chemical and natural methods of fish removal will improve the natural quality of wilderness quality by eliminating human-caused threats caused by stocked fish in naturally fishless lakes.
    - Piscicide chemicals may have unintended consequences that could potentially degrade the natural quality of wilderness.
    - Despite careful mitigation measures, there are short-term (< 1 year) negative effects to some non-target species (e.g., immature amphibians) from the chemical and mechanical treatments.
    - Six state-listed special status species (Black-backed woodpecker, Golden eagle, Lewis' woodpecker, Merlin, Pileated woodpecker and Vaux's swift) would incur short-term negligible to minor adverse impacts, and the common loon would incur long-term minor to moderate adverse impacts due to the removal of fish which is a primary food source for it, particularly at Hozomeen Lake (NPS 2008, pg 131, 194).

Solitude or Primitive and Unconfined Recreation

- *Removing fish*
    - It will take many years to treat all of the lakes slated for fish removal in the MLFMP. During the MLFMP implementation, there will be moderate to severe adverse impacts on visitor experience from helicopter use during implementation and monitoring of fish removal actions, which is both audibly and visibly intrusive to visitors.
    - Motorized equipment used in the application of piscicides using outboard motors and pumps may negatively affect the solitude quality of wilderness character.

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[4] http://www.wilderness.net/toolboxes/documents/WC/Keeping%20it%20Wild%20Interagency%20Strategy%20GTR-212.pdf

- Lakes treated with chemicals will be closed during implementation and for a short time (up to one month) thereafter for safety reasons, which restricts visitor experiences in the short term.

Undeveloped

- *Fish Removal*
  - The use of motorized equipment such as helicopters, electric trolling motors boats and electric bilge pumps to apply chemical piscicides degrades the undeveloped quality of wilderness character.
  - Thus far, _____hours of helicopter use and _____hours of motorboat use have occurred during fish removal operations.

Unique Qualities or Other Features of Value

- *Removing fish*
  - This quality would not be affected by fish removal.

Risks and Uncertainties of the Restoration Treatment

Both antimycin and rotenone are pesticides derived from natural sources and pose the greatest risk to gill-breathing aquatic organisms. When applied appropriately, these piscicides do not pose a significant risk to algae, aquatic macrophytes, terrestrial organisms, or human health (see appendix 4 for more details). Tailed frogs are the most sensitive non-target species to the effects of rotenone, in particular tailed frog larvae. However, tailed frog larvae inhabit streams during their larval stage and therefore negative effects would be limited given the neutralizing agent that is applied at the stream outlet of each chemically treated lake.

Antimycin was only used in early MLFMP treatments and is no longer commercially available, but its application in large alpine lakes was viewed as "pushing the envelope" in the field of restoration ecology[5]. The use of new, or experimental, approaches in the Stephen Mather Wilderness involves uncertainties related to treatment efficacy and the risks of unintended consequences, which may have impacts on the untrammeled and natural qualities of wilderness character.

When reflecting on the obstacles of implementing the MLFMP and beginning the fish removal process, Ashley Rawhouser, Aquatic Ecologist at NOCA, stated that the greatest obstacle was balancing the conflicting Wilderness Act mandate to protect both the natural and untrammeled qualities of wilderness character[6]. Although implementing the MLFMP would increase the natural quality of wilderness over the long term, there would be a significant degradation of the untrammeled quality of wilderness during the eradication of non-native fish. As highlighted by park policy and the mission of the NPS, NOCA values the restoration of ecosystems that have been degraded by past human actions. NPS policy advocates for restoring native ecosystems, and this culture permeates the natural resources division of most parks because the staff is directly witnessing and documenting the degradations of native ecosystems as part

[5] Personal communication with Ashley Rawhouser 10/30/2014
[6] Personal communication with Ashley Rawhouser 10/30/2014.

of their daily work. This is a case that highlights the occasional incompatibility of laws that a wilderness decision-maker must make. NPS law and policy advocate for restoring degraded ecosystems and preserving the natural characteristics of the landscape, while the Wilderness Act stresses the need for humility and restraint in making decisions that manipulate or control the wilderness.

RESTORATION OUTCOMES

Due to variability in annual funding, implementing the MLFMP has been carried out in incremental stages (see appendix 3). As of Fall 2015, Rawhouser states, "NOCA has been working to remove fish in 10 lakes, successfully removing non-native eastern brook trout from three of those lakes and removing westslope cutthroat trout in five lakes, and golden trout from one lake using a combination of gillnetting and rotenone treatments.[7]."

The outcome of the fish removal so far has been successful, as is evident in the sharp rise in amphibians observed around the lakes. For example, the year after fish were removed from Diobsud Lakes, 20 amphibians were detected; three years after the treatment, 667 amphibians were observed (NPS 2014c). According to project leaders, one of the greatest successes of the fish removal thus far has been witnessing an increase in insect productivity and avian activity observed around the lakes. Due to these observations, bird and bat activity will now be monitored in the future as part of the mountain lakes monitoring protocol. These observations provide evidence that the natural quality of wilderness character is improving from fish removal actions.

An unforeseen consequence occurred in 2010, when a netting survey of Lower and Middle Blum Lakes detected the presence of illegally stocked fish after the chemical treatment had been applied[8].
Due to the scale of aquatic interventions at NOCA to implement the MLFMP, including a vast array of fish removal and fish stocking actions, the wilderness character is undoubtedly affected by both management actions of fish removal and fish stocking. Future actions include two years of invasive monitoring techniques such as gillnetting to verify that the chemical removal was successful, and following that, less invasive techniques of annual monitoring. Due to funding restrictions, not every lake will be monitored each year.

According to project leaders, information gathered from monitoring the alpine lakes will be used to manage wildfire activities, prevent the spread of amphibian disease, manage visitor use density, identify refugia for sensitive species, and develop management strategies to protect certain species in the face of climate change. Moreover, the monitoring will be used to help guide the implementation of the MLFMP as an adaptive management strategy.

CONCLUSIONS

[7] Personal communication with Ashley Rawhouser 10/30/2014
[8] Personal communication with Ashley Rawhouser 10/30/2014

One of the stated objectives in the MLFMP is to, "advance the protection and rehabilitation of native biological integrity by maintaining native species abundance, viability, and sustainability" (NPS 2008, p. 5). Based on data from the treated lakes, the removal of non-native fish has resulted in an increase in native species abundance and diversity. However, with the passage of the North Cascades National Park Service Complex Fish Stocking Act of 2014, up to 42 lakes could be stocked in the future.

Implementing the MLFMP requires a decision trade-off for wilderness managers. If managers choose not to act, the natural quality of the Stephen Mather Wilderness will continue to degrade over time and the genetic integrity of native fish in the lower streams could be compromised, along with a variety of native amphibian species; as well as suppressed avian and insect activity. Restoring 38 alpine lakes will degrade the untrammeled quality of wilderness character, even if the goal is to restore native biodiversity and improve the natural quality of wilderness character. In this case, wilderness character cannot be preserved in its entirety, but if the goal is to preserve native species and remove a human-caused threat thereby improving natural conditions, as NPS policy states, removing non-native fish will most likely accomplish those goals.

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Washington Park Wilderness Act of 1988. Public Law 100-668.

AGENCY STAFF CONSULTED

Elizabeth Boerke, Environmental Protection Specialist, North Cascades National Park (personal communication 12/1/14)

Jack Oelfke, Chief of Natural and Cultural Resources, North Cascades National Park (personal communication)

Ashley Rawhouser, Aquatic Ecologist, North Cascades National Park (personal communication 10/30/14)

Roy Zipp, Environmental Protection Specialist, North Cascades National Park (personal communication 11/5/2014)

APPENDIX 1: LAWS AND POLICIES

The Stephen Mather Wilderness is managed in accordance with the provisions of the following laws and policies.

Laws

The Wilderness Act of 1964 (PL 88-577)

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 and states that "An area of wilderness...which is protected and managed so as to preserve its natural conditions and which (1) generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable" (PL 88-577).

Washington Park Wilderness Act of 1988 *(PL 100-668)*

Title II Section 201 of this Act designated 93% of North Cascades National Park Service Complex as designated Wilderness, totaling 634,614 acres, to be managed in accordance with the Wilderness Act of 1964. This Act also designated wilderness areas in Olympic and Mount Rainier National Parks.

Enabling Legislation (PL 90-544)

North Cascades National Park Service Complex (which includes North Cascades National Park, Ross Lake National Recreation Area and Lake Chelan National Recreation Area) was established in 1968 by an act of Congress. It was established, "in order to preserve for the benefit, use, and inspiration of present and future generations certain majestic mountain scenery, snowfields, glaciers, alpine meadows, and other unique natural features in the North Cascade Mountains of the State of Washington" (82 Stat. 926).

National Park Service Organic Act of 1916 (16 U.S.C. l-4)

The Organic Act established the National Park Service with a mission, "to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations." The Act prohibits the NPS from allowing the impairment of park resources

and values (16 USC, sections 1-4). In accordance with this Act, removing non-native fish would be allowed if the presence of these fish were causing impairment of park resources.

The North Cascades National Park Service Complex Fish Stocking Act of 2014 (PL 113-137)

This Act was sponsored by Republican representative Doc Hastings of Washington State, and signed by President Obama on July 25, 2014. The Act directs the Secretary of the Interior to continue fish stocking in not more than 42 of the 91 that have historically been stocked with fish. This Act dramatically influences the implementation of the MLFMP by changing from the environmentally preferred alternative of "D" to "Alternative B" which allows for stocking in up to 42 of the lakes that have historically been fishless. This legislation conflicts with other federal laws and NPS policy applicable to the stewardship of the Stephen Mather Wilderness.

Policies and Management Directives

National Park Service Director's Order 41, Wilderness Stewardship (2013)[10]

National Park Service Management Policies (2006)[11]

4.4.1.1 Plant and Animal Population Management Principles

To meet its commitments for maintaining native species in parks, the Service will cooperate with states...as appropriate to prevent the introduction of exotic species into units of the national park system, and remove, when possible, or otherwise contain individuals or populations of these species that have already become established in parks.

4.1.5 Restoration of Natural Systems

The Service will reestablish natural functions and processes in parks unless otherwise directed by Congress. Landscapes disturbed by natural phenomena, such as landslides, earthquakes, floods, hurricanes, tornadoes, and fires, will be allowed to recover naturally unless manipulation is necessary to protect other park resources, developments, or employee and public safety. Impacts on natural systems resulting from human disturbances include the introduction of exotic species; the contamination of air, water, and soil; changes to hydrologic patterns and sediment transport; the acceleration of erosion and sedimentation; and the disruption of natural processes. The Service will seek to return such disturbed areas to the natural conditions and processes characteristic of the ecological zone in which the damaged resources are situated. The Service will use the best available technology, within available resources, to restore the biological and physical components of these systems, accelerating both their recovery and the recovery of landscape and biological community structure and function.

4.4.4.2 Removal of Exotic Species Already Present

All exotic plant and animal species that are not maintained to meet an identified park purpose will be managed-up to and including eradication-if (1) control is prudent and feasible, and (2) the exotic species interferes with natural processes and the perpetuation of natural features, native species or natural habitats, or disrupts the genetic integrity of native species…High priority will be given to managing exotic species that have, or potentially could have, a substantial impact on park resources, and that can reasonably be expected to be successfully controlled.

[10] http://www.nps.gov/policy/DOrders/DO-41%28Corr%29.pdf
http://www.nps.gov/policy/mp/chapter4.htm

[11] http://www.wilderness.net/NWPS/documents/NPS/2006%20Wilderness%20Management%20Policies.pdf

6.3.7 Natural Resources Management

The principle of nondegradation will be applied to wilderness management, and each wilderness area's condition will be measured and assessed against its own unimpaired standard. Natural processes will be allowed, insofar as possible, to shape and control wilderness ecosystems. Management should seek to sustain the natural distribution, numbers, population composition, and interaction of indigenous species. Management intervention should only be undertaken to the extent necessary to correct past mistakes, the impacts of human use, and influences originating outside of wilderness boundaries.

Site-Specific Planning Documents

Ross Lake Recreation Area General Management Plan (2012)
Final Mountain Lakes Fishery Management Plan/EIS (2008)
Lake Chelan National Recreation Area General Management Plan (1995)
Wilderness Management Plan (1989)
North Cascades National Park Service Complex General Management Plan (1988)

APPENDIX 2: PRINCIPLES FOR MANAGING THE MOUNTAIN LAKES

TABLE 2: PRINCIPLES FOR MANAGING THE MOUNTAIN LAKES FISHERY TO CONSERVE BIOLOGICAL INTEGRITY (NPS 2008, p. 10)

1. A prudent and precautionary management strategy should protect all lakes that are currently fishless. A lake that is fishless today would remain fishless in the future.

2. Reproducing populations of fish that have achieved high densities would be removed from all lakes where feasible. Following removal, the biological conditions of the lakes would be monitored for recovery. Monitoring results would be used to decide whether or not the lake could be stocked with low densities of nonreproducing fish.

3. Lakes that serve as high-quality breeding and rearing habitat for amphibians and are located within the range of long-toed salamanders, generally would be returned to a fishless condition, or low densities of nonreproducing fish would be allowed if no other criteria applied. However, observations indicate that certain lakes have complex habitat conditions, such as extensive shallow areas and woody debris, which would allow amphibian populations to persist in spite of fish predation or competition. Where a lake has a long history of stocking and salamanders are known to exist sympatrically (together in the same area; for example, Coon Lake), nonreproducing fish would be stocked at low densities.

4. Certain lakes would be managed as fishless due to unique features. These features include the presence of a species of conservation concern; large, deep lakes in fishless conditions (which are underrepresented in the North Cascades Complex); geologically unique lakes; and geographically isolated lakes. Geographically isolated lakes need to remain fishless to protect metapopulations of salamanders. A lake was considered isolated if (1) it was more than 2,000 feet from other permanent water bodies, (2) it was within the range of long-toed salamanders, and (3) there was no evidence that salamanders and fish could survive sympatrically. Lakes that possessed these unique features were

considered on a larger landscape scale to determine if fishless conditions were represented among these lake types. A lake that belonged to an underrepresented type in the study area would be returned to a fishless condition.

5. Benthic (bottom dwelling) macroinvertebrate monitoring data (collected through the NPS long-term ecological monitoring program) indicate that certain lakes have suppressed populations of macroinvertebrates. A lake with suppressed populations of macroinvertebrates would become fishless or would be evaluated further before determining final management action.

6. In closely grouped lakes, fishless conditions in at least one lake would be maintained to provide fishless habitat for aquatic organisms in the localized area.

7. Where key information for a given lake was lacking for this stage of planning, the lake would be evaluated before management actions would be recommended.

8. Lakes that do not possess any of the identified risk factors (decision criteria) would be considered for stocking to maintain fish densities commensurate with the protection of biological integrity.

For a lake that is currently fishless:

1 The lake would remain fishless.

For a lake with high densities of reproducing fish, apply one of the following management actions:

2A Remove all reproducing fish. Monitor the recovery of native organisms and keep the lake fishless.

2B Remove all reproducing fish. Monitor lake conditions and use the results to determine whether or not to restock the lake with nonreproducing fish. If the lake is restocked and monitoring results indicate fish are causing major adverse impacts, then fish densities would be reduced by changing stocking densities, stocking cycles or the species of stocked fish. If these management changes do not work, then discontinue stocking.

2C Remove all reproducing fish. Implement a resting period (that is, keep the lake fishless for a period of time) to foster recovery of native organisms. The duration of the resting period will be determined on a lake-by-lake basis based upon monitoring results. If monitoring results indicate favorable recovery of native organisms, then restock the lake with low densities of nonreproducing fish and monitor lake conditions. If monitoring results indicate fish are causing

major adverse impacts, then reduce stocking densities, stocking cycles, or the species of stocked fish. If these management changes do not work, then discontinue stocking.

For a lake with low densities of reproducing fish, apply one of the following management actions:

3A Remove all reproducing fish. Monitor the recovery of native organisms, and keep the lake fishless.

3B Evaluate the reproductive status of fish and the status of indicator taxa. If fish density is high enough that impacts on indicator taxa may be major, apply prescription 2A, 2B, or 2C. If fish densities and

impacts to indicator taxa are low, maintain the low fish densities. If monitoring data indicate fish are causing major adverse impacts, then completely remove fish.

3C For lakes with extremely low densities of fish, augment the population with supplemental stocking and monitor indicator taxa. If monitoring results indicate fish are causing major adverse impacts, then stop stocking and remove all fish.

For a lake that has been stocked and does not contain a reproducing population of fish, apply one of the following management actions:

4A Discontinue stocking. Monitor the recovery of native organisms.

4B Lack of data for decision-making. Discontinue stocking and monitor lake conditions. If the lake is restocked and monitoring results indicate fish are causing major adverse impacts, then discontinue stocking.

4C Continue stocking with low densities of fish expected not to reproduce in the lake. If monitoring results indicate fish are causing major adverse impacts, then reduce stocking densities, stocking cycles or the species of stocked fish. If these management changes do not work, then discontinue stocking.

Scale of action (NPS 2014C)

Management prescriptions for lakes with no fish or with high densities of reproducing fish:
1A – 29 lakes
2A – 8 lakes
2B – 8 lakes
2C – 11 lakes

Management prescriptions for lakes with low densities of reproducing fish:
3A – 0 lakes
3B – 7 lakes
3C – 2 lakes

Management prescriptions for lakes previously stocked with non-reproducing fish:
4A – 12 lakes
4B – 5 lakes
4C – 9 lakes

An example of this is seen below.

Lake Name	NPS Lake Code	Level of Visitation in 2003	Alt A	Alt B	Alt C	Alt D	Forest	Shrub	Meadow	Talus	Bedrock Cliff
Blum (Largest/Middle, No. 3)	M-11-01 M X X-2B	0	2A	2A	0	47	0	53	0		

APPENDIX 3: AUTHORIZED ACTIONS TAKEN TO REMOVE NON-NATIVE FISH

Year	Jeanita	Upper Triplet	Lower Triplet	Diobsud #1	Diobsud #2	Sourdough	Middle Blum	Lower Blum	Kettling
2007	IA								
2008		IA	IA	IA	IA		IA	IA	
2009		GN	GN	GN	GN		CT	CT	
2010		GN	GN	GN	GN	IA	MT, GN	MT, GN	IA
2011		GN	GN	GN	GN	IA / GN	MT, GN	MT, GN	
2012	GN	GN	GN	MT	GN	MT	MT, GN	MT, GN	
2013	GN	GN	GN	MT	GN	CT	MT, GN	MT, GN	
2014	MT	MT	GN	MT	GN	MT	MT, GN	MT, GN	CT
2015		MT			GN	MT	GN	GN	MT

IA = initial assessment (not a trammeling action)
GN = active gillnetting (trammeling action)
CT = chemical treatment (trammeling action)
MT = monitoring treatment (not a trammeling action)

APPENDIX 4: PISCICIDES USED FOR FISH REMOVAL

A Closer Look at the Chemicals: Antimycin and Rotenone

- Antimycin is an antibiotic complex that is derived from the bacterium Streptomyces griseus. The liquid formulation of antimycin used for fish removal is called Fintrol (NPS 2013).
- Rotenone is an alkaloid extracted from the roots of plants in the bean family. Although rotenone is less toxic than antimycin to fish and non-target organisms, the piscicidal concentration for eradicating trout is higher is much higher (up to 50 parts per billion versus only 8 parts per billion for antimycin. Rotenone has been used successfully in 15 of 44 piscicidal treatments in national parks. The liquid formulation used for fish removal is called, CFT Legumine (NPS 2013).
- Both chemicals are naturally occurring and are part of the bean family. They are listed as Organic Pesticides and both break down with exposure to sunlight and have a very short half-life (days).
- Salmonids are the most sensitive taxa to both chemicals, classified as highly toxic for them. Amphibians are most sensitive to piscicides during their larval (gill-breathing) life history stage (Gilderhus et al. 1969, Ling 2003, Grisak et al. 2007), and piscicide treatments using either rotenone or antimycin would likely have impacts on larval amphibians when they are present. However, impacts to tailed frog, for both rotenone and antimycin, are expected to be limited since this species inhabits streams during its larval stage and only small sections of lake-outlet habitat are expected to be impacted. It should also be noted that amphibian surveys conducted in lakes with naturally reproducing populations of fish have not detected any larval amphibians (NPS 2008).
- Studies demonstrate that invertebrate populations will recover after exposure to piscicide concentrations of rotenone in whole lake experiments (Blakely et al. 2005, Havens 1980).