APPENDIX A: MINIMUM REQUIREMENTS ANALYSIS

SEQUOIA AND KINGS CANYON NATIONAL PARKS

MINIMUM REQUIREMENTS ANALYSIS
AND WORKSHEET

“. . . except as necessary to meet minimum requirements for the administration of the area for the purpose of this Act...”

– The Wilderness Act, 1964

Instructions:

A Minimum Requirement Analysis (MRA) is required for ***all*** administrative actions in wilderness that either propose a Wilderness Act Section 4(c) prohibited use or have an effect on wilderness character (per Director’s Order 41). **See the Minimum Requirement Instructions for directions and background materials to assist you with this analysis**. Additional instructions may be found at: http://www.wilderness.net/mrdg/

Routing Information:

1) Complete the Minimum Requirement Analysis Worksheet (MRA). Name the file as follows: SubmissionDate_ShortTitle_LastName_Version1.docx.
2) Email the MRA (WORD version) to the Assistant Wilderness Coordinator (AWC) (alison_steiner@nps.gov) and the Environmental Protection Specialist (EPS) (nancy_hendricks@nps.gov) for review. **You must submit your MRA at least two weeks before your proposed action is to occur.**
3) **If revisions are necessary**, the EPS will:
    a. Return the MRA to the project proponent for revisions. Once revisions are made, project proponent will rename file as Version2. Then, repeat Step 2.

    If no revisions are needed, the EPS will:
    a. Rename the file as Final and save it under: S:\SUPT\Environmental Compliance Office\Wilderness\MRMTs and MRAs*Year*\Final
    b. Forward the electronic copy to the Division Chief for review and signature and “cc:” the project lead.
4) Division Chief will review and forward a printed copy to the Superintendent for signature. If the Division Chief changes the MRA, they will return the updated version electronically to the AWC and EPS. **If the MRA is part of a larger environmental compliance or permitting package, the entire package must go to the Superintendent for review/signature at the same time.**

5) The signed MRA will be sent to the EPS for record keeping. Signed/scanned copies will be filed as PDFs under: S:\SUPT\Environmental Compliance Office\Wilderness\MRMTs and MRAs*Year*\Signed MRAs

6) The EPS will email a PDF of the signed MRA Worksheet to the project proponent so that he/she can review mitigation, monitoring, and reporting requirements.

GENERAL INFORMATION:

Project Title:____ Restoration of High Elevation Aquatic Ecosystems ___

Project Duration:________With approval of the project (currently EIS is being prepared) it would be a 20-35 year project_______________________________
(For longer projects, review the MRA yearly to determine accuracy. Prepare a new MRA if the project is modified, new prohibited actions are proposed, or at a minimum every 5 years.)

Date Submitted:_____4/4/2013____

Project Proponent:___Danny Boiano___________________________________

Contact Information: ______559-565-4273________________________________

Tracking Number (Office Use Only):_____SEKI-2013-MRA-01________________

Step 1: Determine if any administrative action is necessary.

Description of Situation: What is the situation that may prompt administrative action? What is the reason that you are proposing an action (or actions) in wilderness? Do not describe the action itself. Rather, describe the desired goal or outcome.

The overall goal of this project is to restore clusters of fishless waters in strategic locations across the park to create high elevation ecosystems having more favorable habitat conditions for the persistence of native species (including mountain yellow-legged frogs/MYLFs) and natural ecosystem processes.

Historically, high elevation lakes within SEKI were fishless and provided habitat for a diverse assemblage of native species that developed over thousands of years in a fishless environment. From the 1860s to 1988, nonnative fish including rainbow/golden trout hybrids, brook trout and brown trout were introduced by humans into many fishless waters throughout SEKI. By the early 1900s, MYLFs generally became rare to extinct in lakes containing nonnative fish, while remaining common to abundant in most fishless lakes (Grinnell and Storer 1924). Surveys completed in 2002 determined that self sustaining nonnative fish populations had become established in approximately 575 lakes, ponds, and marshes, plus hundreds of miles of connecting streams (after the current project is completed there will be 549 waterbodies containing self-sustaining populations of nonnative fish). All of these waters are located above approximately 8,000 feet in elevation and within SEKI lands designated or managed as wilderness.

The impacts of nonnative trout on high-elevation aquatic and adjacent terrestrial ecosystems are well documented and occur at all levels of the food web (Bradford et al. 1998, Knapp and Matthews 2000, Knapp et al. 2001, Matthews et al. 2001, Matthews et al. 2002, Knapp 2005A, Herbst et al. 2009, Pope et al. 2008, Epanchin et al. 2010). Nonnative trout impact native species directly through predation (Vredenburg 2004) and indirectly through competition for food resources (Finlay and Vredenburg 2007). Nonnative trout can disrupt the type and distribution of species, and thus the natural function of aquatic ecosystems. For example, researchers found that the distribution and abundance of MYLFs (Knapp et al. 2005), conspicuous aquatic invertebrates (e.g., mayflies; Bradford et al. 1998) and zooplankton (e.g., Daphnia; Knapp and Sarnelle 2008) were dramatically reduced by the introduction of nonnative trout.

Particularly vulnerable are two species that are integral components of SEKI's high elevation aquatic ecosystems: the MYLFs (Rana muscosa and Rana sierrae). Nonnative trout prey on MYLFs, compete with them for food, restrict their breeding to marginal, shallow habitat, and fragment remaining populations (Bradford et al. 1993, Knapp and Matthews 2000, Vredenburg 2004, Finlay and Vredenburg 2007).

Excerpted from the Federal Register Notice (Federal Register Vol. 78, No. 80, April 25, 2013) Proposed Rule to list the MYLF as Endangered Species:

> The body of scientific research has demonstrated that introduced trout have negatively impacted mountain yellow-legged frogs over much of the Sierra Nevada (Grinnell and Storer 1924, p. 664; Bradford 1989, pp. 775–778; Bradford et al. 1993, pp. 882–888; Knapp 1994, p. 3; Drost and Fellers 1996, p. 422; Knapp 1996, pp. 13–15; Knapp and Matthews 2000, p. 428; Knapp et al. 2001, p. 401). Fish stocking programs have negative ecological implications because fish eat aquatic flora and fauna, including amphibians and invertebrates (Bahls 1992, p. 191; Erman 1996, p. 992; Matthews et al. 2001, pp. 1135–1136; Pilliod and Peterson 2001, p. 329; Schindler et al. 2001, p. 309; Moyle 2002, p. 58; Epanchin et al. 2010, p. 2406). Finlay and Vredenburg (2007, p. 2187) documented that the same benthic (bottom-dwelling) invertebrate resource base sustains the growth of both frogs and trout, suggesting that competition with trout for prey is an important factor that may contribute to the decline of the mountain yellow-legged frog. Knapp and Matthews (2000, p. 428) surveyed more than 1,700 water bodies, and concluded that a strong negative correlation exists between introduced trout and mountain yellow-legged frogs (Knapp and Matthews 2000, p. 435). Consistent with this finding are the results of an analysis of the distribution of mountain yellow-legged frog tadpoles, which indicate that the presence and abundance of this life stage are reduced dramatically in fish-stocked lakes (Knapp et al. 2001, p. 408). Knapp (2005a, pp. 265–279) also compared the distribution of nonnative trout with the distributions of several amphibian and reptile species in 2,239 lakes and ponds in Yosemite National Park, and found that mountain yellow-legged frogs were five times less likely to be detected in waters where trout were present. Even though stocking within the National Park ceased in 1991, more than 50% of water bodies deeper than 4 m (13 ft) and 75% deeper than 16 m (52 ft) still contained trout populations in 2000–2002 (Knapp 2005a, p. 270). Both trout and mountain yellow-legged frogs utilize deeper water bodies. Based on the results from Knapp (2005a), the reduced detection of frogs in trout-occupied waters indicates that trout are excluding mountain yellow-legged frogs from some of the best aquatic habitat.

A second factor in the decline of the MYLF is the recent spread of chytridiomycosis, a disease caused by amphibian chytrid fungus (*Batrachochytrium dendrobatidis* or Bd), which has infected and imperiled most remaining MYLF populations (Rachowicz et al. 2006, Vredenburg et al. 2010) in SEKI leading to a more urgent situation that needs to be addressed as soon as possible.

Background

Since 2001, SEKI has been conducting restoration projects in several basins on a limited scale. The primary method has been through the removal of nonnative trout from water bodies, along with research and monitoring of native species at the removal areas. The results have shown recovery of native species, particularly MYLFs, at the treatment areas. However, recently, the chytrid fungus has spread within SEKI and has decimated populations of MYLF, resulting in increased likelihoods of population die-offs and extirpation of both species. Studies indicate it recently spread into the Sierra Nevada (Rachowicz et al. 2005, Morgan et al. 2007; Vredenburg et al. 2010) and has infected nearly all remaining MYLF populations including those in SEKI and YOSE. Most MYLF populations have severely declined within a few years after becoming infected and some populations have gone extinct. Chytrid fungus has thus been a major factor in accelerating the decline of MYLFs caused by nonnative fish throughout the Sierra Nevada.

The MYLF only occur in high elevation aquatic ecosystems (above 8,000 feet) which are all located in wilderness. The largest remaining populations of these two species are located within SEKI wilderness. Studies in the past decade determined that MYLF populations have disappeared from approximately 92% of historic localities in the Sierra Nevada including SEKI (Vredenburg et al. 2007). This decline has largely been attributed to the widespread introduction of nonnative fish (Bradford et al. 1994B, Knapp and Matthews 2000) and the recent emergence of disease (Rachowicz et al. 2006). Today the MYLFs are among the world's most critically endangered amphibians; most of the remaining populations are much smaller and more isolated than they were historically (Vredenburg et al. 2007). MYLFs and their critical habitat were proposed for listing as Endangered under the federal Endangered Species Act in April 2013. (78 Fed. Reg. 24472.) A final decision by the U.S. Fish and Wildlife Service is expected in 2014.

The FWS, NPS, USFS and CDFW are currently collaborating on the development of the Mountain Yellow-legged Frog Complex Conservation Strategy (USFS in preparation). The Conservation Assessment is being developed as a tool to guide future conservation strategy and recovery planning for the Sierra Nevada MYLFs. The draft Conservation Assessment concludes that introduced fish played a major role in the decline of the species likely causing local extirpations, and may have precluded successful recolonization. The Conservation Assessment identifies restoring fishless habitat and developing a translocation study as key conservation actions for recovering the species. The goal of the Conservation Strategy is to "ensure self-sustaining long-term viability and evolution of mountain yellow legged frog populations in perpetuity that represent their historic geographical range, and genetic and ecological diversity." The multi-agency team developing the strategy has concluded that eradicating introduced fish and developing methods for successful translocations are the primary tools available for recovering MYLFs.

The existence of nonnative trout, and subsequently the spread of the infectious chytrid fungus (Bd) throughout its habitat, has created a dire situation. Other stressors include changing climatic conditions and air pollution. Air pollution may stress the MYLF immune systems. Global climate change has caused smaller, shallower lakes, which are important habitat because they are fishless, to dry up earlier in the season, thus further impacting the MYLF which need two years to successfully grow from tadpole to adult form.

The MYLFs' decline has had cascading negative consequences to high elevation ecosystems across the Sierra Nevada. Because of the historic abundance of MYLFs (Grinnell and Storer 1924), they were important contributors to energy and nutrient cycling in aquatic and adjacent terrestrial ecosystems. Eradicating nonnative fish from high quality MYLF habitat and restoring MYLF populations to locations where they have been extirpated would also restore and protect an integral component of healthy high Sierra native ecosystems (Knapp et al. 2001) which is integral to protecting the natural quality of wilderness character.

Action in wilderness is necessary at this time because it is critical to protect these species and their habitat in order to prevent future impairment to ecosystem processes in high elevation aquatic ecosystems within the SEKI wilderness that would occur as a result of the extinction of these species in SEKI.

To determine if administrative action is necessary, answer the questions listed in A - F on the following pages by answering Yes or No, and providing an explanation.

A. Are there options outside of wilderness?

Justify why the action is necessary within wilderness.

Yes: ☐ **No:** ☒

Explain:

Over 99% of SEKI's MYLF habitat is located in the wilderness at elevations over 8,000 feet. There have been alternative approaches considered that could occur outside wilderness, including captive rearing programs. Implementing a MYLF captive rearing program for reintroduction into the wild was considered as a restoration tool to supplement nonnative fish eradication and natural recolonization. However, it would be pointless to transplant MYLF into habitat if nonnative fish are not removed in wilderness lakes prior to reintroductions. Frog restoration using only reintroductions would not address the issues with fragmented populations and the availability of high quality fish-free habitat. Also, the reintroductions would have to occur across the MYLF habitat, of which 99% is located in wilderness areas.

This project looks at restoration of natural conditions on a landscape scale as large scale restoration of more complex habitat is critical for native species and ecosystem processes. Since 99% of MYLF habitat is located in wilderness, large scale restoration cannot occur outside of wilderness. Therefore it is necessary to conduct actions within wilderness.

B. Are there valid existing rights or special provisions of wilderness legislation?

Is action necessary to satisfy valid existing rights or a special provision in wilderness legislation (the Wilderness Act of 1964 or subsequent wilderness laws) that allows or requires consideration of the Section 4(c) prohibited uses? Cite law and section.

Yes: ☐ **No:** ☒

Explain:

C. Are there requirements of other legislation?

Is action necessary to meet the requirements of other laws? Cite law and section.

Yes: ☒ **No:** ☐

Explain:

California Wilderness Act of 1984 (Public Law 98-425)

Though not specifically contained within the legislation, conservation is a valid goal of the Sequoia-Kings Canyon Wilderness. The Committee Report (House Report 98-40) accompanying the House version of the 1984 act states that "native wildlife species are an integral and natural component of the character of a wilderness on an interdependent basis with its physical features: soils, water, geology and plants.

Endangered Species Act of 1973 (16 U.S.C. 1531-1544, 87 Stat. 884), as amended – PL 93-205

The Endangered Species Act was enacted to provide a program for the conservation of wildlife and plant species that are threatened or endangered with extinction. The Act provides that federal agencies shall "utilize their authorities in furtherance of the purposes of [the Act] by carrying out programs for the conservation of endangered species and threatened species." 16 U.S.C. Section 1536(a)(1). The Act further requires Federal agencies to ensure that any action authorized, funded or carried out by them is not likely to jeopardize the continued existence of listed species or modify their critical habitat.

Section 7(a)1 of the ESA 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 and threatened species ..." Under ESA section 4(f) authority, the Secretary of Interior, through the USFWS, is charged with developing and implementing recovery plans for the conservation and survival of threatened and endangered species. By restoring MYLF to its historic range, the project fulfills a necessary component of the Draft Conservation Strategy and facilitates conservation of this species.

The mountain yellow-legged frog (R. muscosa) is a Federal Candidate species for listing under the Endangered Species Act. In the FWS 12-month Finding on a Petition to List this Species, the FWS concluded that declines in the distribution and abundance of the species were primarily attributed to the introduction and subsequent predation of introduced non-native fish (FWS 2003). The isolation of remaining populations and habitat fragmentation as a result of non-native fish introductions has made remaining populations vulnerable to extinction from random events such as disease.

In April 2013, the FWS proposed to list the MYLF as endangered and has proposed to designate critical habitat within SEKI. The following information is summarized from the Federal Register Notice (Federal Register Vol. 78, No. 80, April 25, 2013):

> The Sierra Nevada yellow-legged frog is presently in danger of extinction throughout its entire range, based on the immediacy, severity, and scope of the threats to its continued existence. The justification for listing is that there has been a rangewide reduction in abundance and geographic extent of surviving populations of frogs following decades of fish stocking, habitat fragmentation, and most recently a disease epidemic. Surviving populations are smaller and more isolated, and recruitment in disease-infested populations is much reduced relative to historic norms. This combination of population stressors makes persistence of the species precarious throughout the Sierra Nevada range of the mountain yellow-legged frog.
>
> The current distributions of the Sierra Nevada yellow-legged frog and the northern DPS of the mountain yellow-legged frog are restricted primarily to publicly managed lands at high elevations, including streams, lakes, ponds, and meadow wetlands located within National Forests and National Parks. National Parks with extant (surviving) populations of mountain yellow-legged frogs include Yosemite National Park, Kings Canyon National Park, and Sequoia National Park. In the south (Sierra, Sequoia, and Inyo National Forests; and Sequoia, Kings Canyon, and Yosemite National Parks), modest to relatively large populations (for example, breeding populations of approximately 40 to more than 200 adults) of mountain yellow-legged frogs do remain; however, in recent years some of the largest of these populations have been extirpated (Bradford 1991; Bradford et al. 1994a; Knapp 2002a). Davidson et al. (2002) reviewed 255 previously documented mountain yellow-legged frog locations (based on Jennings and Hayes 1994, pp. 74–78) throughout the historical range and concluded that 83% of these sites no longer support frog populations.
>
> To summarize population trends over the available historical record, estimates range from losses between 69 to 93% of Sierra Nevada yellow-legged frog populations and 86 to 92% of northern DPS of the mountain yellow-legged frog. Rangewide reduction has diminished the number of watersheds that support mountain yellow-legged frogs somewhere between the conservative estimates of 44% in the case of Sierra Nevada yellow-legged frogs and at least 59% in the case of northern DPS of the mountain yellow-legged frogs, to as high as 97% of watersheds for the mountain yellow-legged frog complex across the Sierra Nevada. Remaining populations are much smaller relative to historical norms, and the density of populations per watershed has declined greatly; as a result, many watersheds currently support single metapopulations at low abundances.

A final decision regarding the listing of this species and the designation of critical habitat is expected in 2014.

The following laws have also informed the NPS's consideration on whether to take action in wilderness:

The Organic Act of the National Park Service (NPS):
"Sec.1. …. The service thus established shall promote and regulate the use of the Federal areas known as national parks, monuments, and reservations hereinafter specified by such means and measures as conform to the fundamental purpose of the said parks, monuments, and reservations, which purpose is 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 Organic Act directs us "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 1978 Amendment (a.k.a. Redwoods Act) strengthened the protective functions of NPS and influenced recent decisions regarding resource impairment. "…the protection, management, and administration of these areas shall be conducted in the light of the high public value and integrity of the NPS and shall not be exercised in derogation of the values and purposes for which these various areas have been established…"

The National Park Service Omnibus Management Act of 1998
The National Park Service Omnibus Management Act of 1998 directs the Secretary of the Interior "to assure that management of units of the National Park System is enhanced by the availability and utilization of a broad program of the highest quality science and information." It also established the framework for fully integrated natural resource monitoring into the management process of the NPS. Section 5934 of the Act requires the Secretary of the Interior to develop a program of "inventory and monitoring of NPS resources to establish baseline information and to provide information on the long-term trends in the condition of the National Park System resources." The message of the Parks Omnibus Management Act of 1998 was reinforced by Congress in the FY 2000 Appropriations bill.

D. Wilderness Character

Is action necessary to preserve one or more of the qualities of wilderness character including: Untrammeled, Undeveloped, Natural, Outstanding Opportunities for Solitude or Primitive and Unconfined Recreation, or Unique Attributes or Other Features that reflect the character of this wilderness area?

Untrammeled: **Yes:** ☐ **No:** ☒

Explain:

Although this action is not necessary to preserve the "Untrammeled" quality of wilderness character, it proposes to correct past intentional human caused manipulation of "the earth and its community of life." This intentional caused manipulation was the stocking of nonnative trout into the high elevation lakes and streams of Sequoia and Kings Canyon National Park, which led to changing ecosystem function and the disappearance of MYLF from approximately 92% of historic localities in the Sierra Nevada including SEKI (Vredenburg et al. 2007, Bradford et al. 1994B, Knapp and Matthews 2000).

Information excerpted from the Federal Register Notice (Federal Register Vol. 78, No. 80, April 25, 2013):

> Habitat modification due to the introduction of trout to historically fishless areas is documented to have a significant detrimental impact to mountain yellow-legged frog populations. The presence of trout from historical stocking for the creation of a sport fishery in the Sierra Nevada started in the late 19th century (Bahls 1992, p. 185; Pister 2001, p. 280). This anthropogenic activity has community-level effects and constitutes the primary detrimental impact to mountain yellow-legged frog habitat and species viability. Prior to extensive trout planting programs, almost all streams and lakes in the Sierra Nevada at elevations above 1,800 m (6,000 ft) were fishless. Several native fish species occur naturally in aquatic habitats below this elevation in the Sierra Nevada (Knapp 1996, pp. 12– 14; Moyle et al. 1996, p. 354; Moyle 2002, p. 25). Natural barriers prevented fish from colonizing the higher elevation headwaters of the Sierra Nevada watershed (Moyle et al. 1996, p. 354). Another detrimental feature of fish stocking is that fish often persist in water bodies even after stocking ceases. Lakes larger than 1 ha (2.5 ac) within Sierra Nevada National Parks were estimated to have from 35 to 50% nonnative fish occupancy, only a 29 to 44% decrease since fish stocking was terminated around two decades before the study (Knapp 1996, p. 1).

This action is new trammeling intended to correct prior human-caused manipulation as described above.

(Note: The specific effects of each alternative are evaluated in Step 3).

Undeveloped: **Yes:** ☐ **No:** ☒

Explain:

Natural: **Yes:** ☒ **No:** ☐

Explain:

This project would restore elements of the natural quality of wilderness character by restoring native wildlife and the communities and ecosystems in which they occur. There is the potential for adverse effects on the natural quality of wilderness during the removal of nonnative fish, to varying degrees depending on which alternative is selected. But the overall benefit and long-term effects from removing nonnative fish in treatment areas would improve the natural quality of wilderness on a landscape scale in portions of SEKI.

As mentioned previously, the effects of introduced nonnative trout on aquatic ecosystems are well documented.

Information excerpted from the Federal Register Notice (Federal Register Vol. 78, No. 80, April 25, 2013):

> Prior to extensive trout planting programs, almost all streams and lakes in the Sierra Nevada at elevations above 1,800 m (6,000 ft) were fishless. Several native fish species occur naturally in aquatic habitats below this elevation in the Sierra Nevada (Knapp 1996, pp. 12– 14; Moyle et al. 1996, p. 354; Moyle 2002, p. 25). Natural barriers prevented fish from colonizing the higher elevation headwaters of the Sierra Nevada watershed (Moyle et al. 1996, p. 354).The body of scientific research has demonstrated that introduced trout have negatively impacted mountain yellow-legged frogs over much of the Sierra Nevada (Grinnell and Storer 1924, p. 664; Bradford 1989, pp. 775–778; Bradford et al. 1993, pp. 882–888; Knapp 1994, p. 3; Drost and Fellers 1996, p. 422; Knapp 1996, pp. 13–15; Knapp and Matthews 2000, p. 428; Knapp et al. 2001, p. 401). Fish stocking has negative ecological implications because fish eat aquatic flora and fauna, including amphibians and invertebrates (Bahls 1992, p. 191; Erman 1996, p. 992; Matthews et al. 2001, pp. 1135–1136; Pilliod and Peterson 2001, p. 329; Schindler et al. 2001, p. 309; Moyle 2002, p. 58; Epanchin et al. 2010, p. 2406).

Perpetuation of natural ecological relationships and processes, and the continued existence of native wildlife populations in largely natural conditions are key components of the natural quality of wilderness character. Experiencing a natural landscape with a full complement of native biodiversity is a key component of the quality of wilderness character. The natural quality of wilderness character in SEKI is being compromised by the extreme decline of the MYLF. Preventing the frog from going extinct and restoring its distribution across SEKI's wilderness is necessary to restore and protect the natural quality of wilderness character. In order to help prevent the MYLF from going extinct, and to restore and protect these qualities of wilderness character, the number and size of viable populations must be substantially increased.

The ecological effects of continuing losses of formerly abundant MYLFs from most of their ranges have been substantial, and current studies indicate that both species are continuing to decline and are on trajectories toward extinction (Vredenburg et al. 2010, Knapp et al. 2011). Because important interactions occur between MYLFs, other aquatic and terrestrial species, and key ecosystem processes, the presence of MYLFs in an ecosystem today indicates a system that has retained much of its native species diversity and ecological function, and thus likely has stronger potential for resistance and resiliency to ecosystem stressors and uncertain future conditions (compared to ecosystems lacking MYLFs) (Finlay and Vredenburg 2007, Knapp et al. 2007).

It should be noted, however, that there could be a short- to long-term adverse effect on the natural quality of wilderness depending on the alternative selected. If piscicide is selected as the method for removing nonnative trout from high elevation waterbodies, there would be adverse effects on other gill breathing organisms. A piscicide is a substance that is toxic to fish and whose intended function is to eliminate undesirable fish from a waterbody. However, gill-breathing stream and lake aquatic vertebrates and invertebrates could be adversely affected by the use of piscicides, and mortality is expected. This would result in an adverse effect on the natural quality of wilderness character.

(Note: The specific effects of each alternative including the effects of piscicide use are evaluated in Step 3).

Outstanding Opportunities for Solitude or Primitive and Unconfined Recreation:

Yes: ☒ **No:** ☐

Explain:

Reestablishing a native species in a wilderness area, independent of the means for reaching that goal, enhances the primitive character of the wilderness by restoring the natural sights and sounds of wilderness.

While there would be a reduction in opportunities for primitive recreation in locations where nonnative fish are removed, 84% of the 549 waterbodies that currently contain nonnative fish would still contain fish and be open to primitive recreation/fishing. Thus, outstanding opportunities for primitive and unconfined recreation would be preserved.

(Note: The specific effects of each alternative are evaluated in Step 3).

Unique Attributes or Other Features of Value that reflect the character of this wilderness, e.g. Cultural Resources:

Yes: ☐ **No:** ☒

Explain:

E. Public Purposes

Is action necessary to protect one or more of the public purposes for wilderness (as stated in Section 4(b) of the Wilderness Act) of recreational, scenic, scientific, educational, conservation, and historical use?

Recreational: **Yes:** ☒ **No:** ☐

Explain: Experiencing native ecosystems including native wildlife is an integral component of wilderness recreation. There would be a reduction in angling opportunities from the removal of nonnative fish from 16% of currently occupied waters; but 84% of the fish-containing waters would continue to exist, protecting the recreational purpose of wilderness.

Scenic: **Yes:** ☐ **No:** ☒

Explain:

Scientific: **Yes:** ☒ **No:** ☐

Explain: Intensive field studies on MYLFs have occurred in SEKI, YOSE, Inyo NF and Sierra NF to help managers better understand the effects of nonnative fish, chytrid fungus, pollution and climate change, and ultimately how to mitigate those effects. Actions that have been performed include marking animals for tracking purposes, removing a small percentage of animals from a population for disease studies both in the lab and field, collecting tissue for genetic analyses, and treating animals with antifungal cleansers and probiotics. This project would continue these research activities. The results from these efforts and new data gained will be used to inform future research and science.

The project would help identify presently incomplete information that is needed for effective conservation and management of aquatic ecosystems and help managers and scientists understand aquatic ecosystem functional integrity, biodiversity, and develop the capacity to adapt to unprecedented rates of human-induced change.

Results from the restoration efforts and new knowledge from research studies would be used to refine program methodologies over time and mitigate impacts that have the potential to occur during restoration.

Educational: **Yes:** ☒ **No:** ☐

Explain: The results from the restoration efforts and new data gained will be used to inform both park managers, scientists, other agencies, and the public about aquatic ecosystems in wilderness, and how changing conditions, including human-induced changes, affect these ecosystems.

Conservation: **Yes:** ☒ **No:** ☐

Explain: Conservation is a valid public purpose of the Wilderness Act, and this project would fulfill this purpose by conserving and protecting native species, and restoring natural ecosystem functions, resulting in improved conservation of wilderness resources.

The Organic Act directs the NPS "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 California Wilderness Act of 1984 (Public Law 98-425) Committee Report (House Report 98-40) accompanying the House version of the 1984 act which established the Sequoia-Kings Canyon Wilderness states that “native wildlife species are an integral and natural component of the character of a wilderness on an interdependent basis with its physical features: soils, water, geology and plants.

Preserving and restoring native wildlife and the communities and ecosystems in which they occur is one of the guiding principles for managing biological resources in national parks per NPS Management Policies 2006 and is among the desired conditions established in SEKI’s Final General Management Plan/Final Environmental Impact Statement (GMP; NPS 2007).

The 2007 GMP establishes a vision for what the parks should be, including broadly defined desired future conditions for natural resources:

The following desired conditions are relevant to the conservation of natural resources, including:

- The NPS will maintain all the components and processes of naturally evolving park ecosystems.
- Populations of native plant and animal species function in as natural a condition as possible except where special management considerations are warranted.
- Native species populations that have been severely reduced or extirpated from the park are restored where feasible and sustainable.
- The NPS will, within park boundaries, identify, conserve, and attempt to recover all federally listed threatened, endangered, or special-concern species and their essential habitats. As necessary, the NPS will control visitor access to and use of essential habitats, and may close such areas to entry for other than official purposes. Active management programs (such as monitoring, surveying populations, restorations, exotic species control) will be conducted as necessary to perpetuate, to the extent possible, the natural distribution and abundance of threatened or endangered species, and the ecosystems upon which they depend. Ongoing consultation related to threatened or endangered species will occur with the FWS should any actions take place in the habitat of such species.
- The NPS will strive to protect the full range of genetic types (genotypes) of native plant and animal populations in the parks by perpetuating natural evolutionary processes and minimizing human interference with evolving genetic diversity.
- The NPS will re-establish natural functions and processes in human-disturbed natural systems in the parks unless otherwise directed by Congress. The NPS will restore the biological and physical components of human-disturbed systems as necessary, accelerating both their recovery and the recovery of landscape and community structure and function. The NPS will seek to return human-disturbed areas to conditions and processes representing the ecological zone in which the damaged resources are situated.
- Exotic species will not be introduced into the parks (except under special circumstances).
- The management of populations of exotic plant and animal species, up to and including eradication, will be undertaken whenever such species threaten park resources or public health and wherever control is prudent and feasible.
- The NPS will identify all state and locally listed threatened, endangered, rare, declining, sensitive, or special concern species and their essential habitats that are native to and present in the parks. These species and their essential habitats will be considered in NPS planning and management activities.

Protecting and reestablishing native species in wilderness enhances the primeval character of an ecosystem and serves a critical conservation purpose.

Historical: **Yes:** ☐ **No:** ☒

Explain:

F. Is there other guidance?

Is action necessary to conform to direction contained in agency policy, unit and wilderness management plans, species recovery plans, or agreements with tribal, state and local governments or other federal agencies?

Yes: ☒ **No:** ☐

Explain:

NPS Management Policies (2006)
The policies direct parks to "maintain as parts of the natural ecosystems…all plants and animals native to park ecosystems." This may be accomplished by "preserving and restoring the natural abundances, diversities, dynamics, distributions, habitats, and behaviors of native plant and animal populations and the communities and ecosystems in which they occur… [and] minimizing human impacts on native plants, animals, populations, communities, and ecosystems, and the processes that sustain them" (Section 4.4.1). Native species are defined "as all species that have occurred, now occur, or may occur as a result of natural processes on lands designated as units of the national park system" (Section 4.4.1). In terms of management within wilderness, the policies note that "[w]ithout natural resources, especially indigenous and endemic species, a wilderness experience would not be possible." However, species need to be managed within the context of the whole ecosystem and "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" (Section 6.3.7).

Section 6.3.7: Natural Resources Management (in wilderness): 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. Management actions, including the restoration of extirpated native species, the alteration of natural fire regimes, the control of invasive alien species, the management of endangered species, and the protection of air and water quality, should be attempted only when the knowledge and tools exist to accomplish clearly articulated goals.

Section 4.6.5
The Service may intervene to manage individuals or populations of native species only when such intervention will not cause unacceptable impacts to the populations of the species or to other components and processes of the ecosystems that support them (Section 4.4.2). Also management is necessary:

- because a population occurs in an unnaturally high or low concentration as a result of human influences (such as loss of seasonal habitat, the extirpation of predators, the creation of highly productive habitat through agriculture or urban landscapes) and it is not possible to mitigate the effects of the human influences; and
- to protect rare, threatened, or endangered species.

Management Policies 2006, Section 4.4.4, addresses the management of exotic species: Exotic species will not be allowed to displace native species if displacement can be prevented.

Section 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.

This project meets the criteria set in Management Policies Section 4.6.5 because past efforts have shown that nonnative fish can be effectively removed (control is prudent and feasible); as explained previously, nonnative fish have been shown to interfere with natural processes and native species; displacement can be prevented; and the MYLF are candidate species for federal listing, will likely be listed in the near term, and are at risk of extinction. Also, the experimental intervention program underway to protect and treat MYLF has not been shown to cause unacceptable impacts to the populations of the species or other components or ecosystem processes.

Documents Related to the Proposed Rule for the listing of Endangered and Threatened Wildlife and Plants; Endangered Status for the Sierra Nevada Yellow-Legged Frog and the Northern Distinct Population Segment of the Mountain Yellow-Legged Frog, and Threatened Status for the Yosemite Toad, and the Proposed Rule for the listing of Critical Habitat for these species:

The Sierra Nevada Mountain Yellow-legged Frog Conservation Assessment
The U.S. Forest Service (USFS) led a multi-agency working group that developed a conservation assessment for the mountain yellow-legged frog in the Sierra Nevada (Brown et al. in preparation). The Conservation Assessment concluded that introduced fish played a major role in the decline of the species likely causing local extirpations, and may have precluded successful recolonization. The assessment identified restoring fishless habitat and developing a translocation study as key conservation options for recovering the species.

The Mountain Yellow-legged Frog Complex Conservation Strategy
The FWS, NPS, USFS, and California Department of Fish and Wildlife (CDFW) are currently collaborating on the development of a conservation strategy for the Sierra Nevada yellow-legged frog (R. sierrae) and the southern mountain yellow-legged frog (R. muscosa). The goal of the Conservation Strategy is to "Ensure self-sustaining long-term viability and evolution of mountain yellow legged frog populations in perpetuity that represent their historic geographical range, and genetic and ecological diversity." The multi-agency team developing the strategy has concluded that eradicating introduced fish and developing methods for successful translocations are the primary tools available for recovering the species.

California Endangered Species Act (CESA) (Fish and Game Code Sections 2050-2116)
Under the CESA, the southern mountain yellow-legged frog (R. muscosa) is listed as Endangered and the Sierra Nevada yellow-legged frog (R. sierrae) is listed as Threatened. The CDFW recommended listing these species following an extensive review of the species status and threats. CDFW has been actively engaged in conservation of the species for over the past ten years and they have documented along with other agencies including the NPS, and research groups, precipitous range-wide declines. In their status review, CDFW concluded that the introduction of non-native fishes and disease are the principle drivers of decline. Their management recommendations include continuing to remove non-native trout from targeted water bodies to benefit resident MYLF populations and to provide fish free habitat for translocations. They also recommended special focus on research directed at reintroducing MYLFs in a Bd-positive environment.

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To determine if an action is necessary in wilderness, review the Step 1 questions in A - F above.
***Note that the answers have varied weight in Step 1:*
Decision: A - D have first priority;
E has second priority;
F has third priority.

Step 1 Decision: Is any administrative action <u>necessary</u> in wilderness?

Is the action “necessary” to ensure wilderness stewardship or preservation? Considerations to help you make this determination: If you do not accomplish the work, would there be unacceptable adverse effects to wilderness? Would you be going against other laws and/or policies?

Yes: ☒ **No:** ☐

Explain: As discussed in previous sections, the proposed project would allow for the preservation of the natural quality of wilderness, and would fulfill the conservation purpose of wilderness by removing nonnative species and restoring native species and natural ecosystem processes in SEKI. However, the project would also result in a long-term effect on the untrammeled quality of wilderness character during removal and restoration activities, and a short-term effect on the undeveloped quality as a result of using mechanized equipment and the placement of temporary installations.

Numerous studies previously cited have shown that the past trammeling actions (the planting of nonnative fish) in SEKI wilderness have adversely affected the natural quality of wilderness in the long-term, and have imperiled the survival of native species, in particular the MYLF. If the two species of MYLF become extinct, it could lead to the impairment of the high elevation ecosystems of these parks, which is in direct opposition to the NPS Organic Act.

While the planting of nonnative fish (the past trammeling action) was halted in 1988, the impacts from this action on the natural quality of wilderness continue. Fish often persist in water bodies even after stocking ceases. Lakes larger than 1 ha (2.5 ac) within Sierra Nevada National Parks (YOSE and SEKI) were estimated to have from 35 to 50% nonnative fish occupancy, only a 29 to 44% decrease since fish stocking was terminated around two decades before the study (Knapp 1996, p. 1). Although stocking no longer occurs in SEKI, nonnative fish had established self-sustaining populations in approximately 575 waterbodies (Knapp 2003) and in hundreds of miles of stream.

Past actions in the wilderness have shown that trammeling actions have been successful in restoring the natural quality of wilderness character. From 1997 to 1999, researchers used gill nets to experimentally eradicate nonnative fish from two park waterbodies, which showed that fish eradication was feasible (Vredenburg 2004). In 2001, SEKI began to implement preliminary (experimental) restoration of MYLFs (NPS 2001). The primary goal was to assess the feasibility of SEKI staff using gill nets and electrofishers to eradicate nonnative fish from low- to moderate-use individual lakes having short associated streams. The purpose of the program was to restore aquatic habitat for native species, with an emphasis on improving the status of imperiled MYLFs. From 2001 to 2012, SEKI removed nearly 48,000 fish from targeted lakes and streams (NPS 2012A, NPS unpublished data). By 2012, fish were fully eradicated from 10 lakes and nearly eradicated from nine lakes.

In nine of the lakes eradicated of fish, MYLFs remained disease-free three years after trout removal. Average tadpole density in these nine lakes increased by 13-fold (from 0.8 to 10.1 per 10 m of shoreline; $P = 0.008$), while average frog density increased by 14-fold (from 0.8 to 11.1 per 10 m of shoreline; $P = 0.004$). One lake showed an overall 49-fold increase from 0.9 to 43.9 individuals per 10 m of shoreline (NPS 2011A). Several of these MYLF populations are now among the largest in the entire range of MYLFs.

To test the mechanism driving the increases in restored MYLF populations, a study compared the change in MYLF density between 1997 and 2005 in 22 fishless control lakes in SEKI and three trout removal lakes, including two of the SEKI restoration lakes and one lake adjacent to the SEKI boundary in the Inyo National Forest (Knapp et al. 2007). The average change in tadpole density in the control lakes and trout removal lakes was +2.3-fold and +35.2-fold, respectively (P = 0.025), while the average change in frog density in the control lakes and trout removal lakes was +0.4-fold and +24.9-fold, respectively (P = 0.0004). Thus, increases in MYLF frog numbers in trout removal lakes result from fish eradication rather than regionally favorable conditions for population growth. These results show that eradicating nonnative trout is highly beneficial to MYLFs.

In addition, monitoring efforts have detected significantly more garter snakes per survey in trout removal lakes (0.15) versus fish-containing lakes (0.02; P=0.014; Figure 4; 2012A). Garter snakes were thus 10 times more likely to be found in fish removal lakes versus fish-containing control lakes where no removal was conducted. Snake detections also increased over time, exhibiting a positive linear relationship with the number of years since trout removal began (Upper Bubbs Creek, R2=0.55, P=0.09 and Upper LeConte Canyon, R2= 0.49, P=0.02) (NPS 2011A). These differences are likely attributable to the presence of increased numbers of MYLFs, which are a primary prey of garter snakes, in fishless lakes versus fish-containing lakes (Knapp et al. 2007). Clark's nutcrackers, Brewer's blackbirds and American robins are now seen opportunistically feeding on MYLFs in restored populations (NPS unpublished data). In addition, abundant mayfly hatches are now a common annual occurrence at most trout removal lakes, providing improved forage for gray-crowned rosy finches and several bat species (NPS unpublished data).

This project proposes new long-term trammeling actions (site-specific trammeling would occur over a period of up to 35 years) to address past trammeling actions which have adversely affected the natural quality of wilderness character. The new trammeling actions would involve removing all of the nonnative fish from about 16% of the approximately 549 waterbodies (lakes, streams, and marshes) that currently contain nonnative fish. Methods for the removal of the fish are discussed within the alternatives section of this MRA. There would also be trammeling actions associated with future research and the experimental treatment of MYLF for chytrid fungus. There would be limited short-term effects on undeveloped as a result of the proposed removal actions (i.e. considered actions include the installation of nets, fish traps, use of helicopters, the creation of temporary and permanent stream barriers, and the establishment of temporary crew camps).

When weighing the long-term effects on the untrammeled and undeveloped qualities of wilderness against the ongoing adverse effects on the natural quality of wilderness from the presence of nonnative fish, a number of elements are considered.

First, the ecological and conservation effects of continuing losses of formerly abundant MYLFs from most of their ranges have been substantial, and current studies indicate that both MYLF species are continuing to decline and are on trajectories toward extinction (Vredenburg et al. 2010, Knapp et al. 2011). Extinction of these species would have a significant adverse effect on the natural quality of wilderness within SEKI because it would remove a species which is important to key ecosystem processes.

Secondly, because important interactions occur between MYLFs, other aquatic and terrestrial species, and key ecosystem processes, the presence of MYLFs indicates an ecosystem that has retained much of its native species diversity and ecological function, which amounts to the preservation of the natural quality of wilderness. Ecosystems with native components, including MYLF, have been shown to have a stronger potential for resistance and resiliency to ecosystem stressors and uncertain future conditions (compared to ecosystems lacking MYLFs) (Finlay and Vredenburg 2007, Knapp et al. 2007). For these reasons, preserving MYLF into the foreseeable future would have a long-term beneficial effect on the natural quality of wilderness.

Third, because of the historic abundance of MYLFs (Grinnell and Storer 1924), they were important contributors to energy and nutrient cycling in aquatic and adjacent terrestrial ecosystems. Removing nonnative fish and restoring MYLF populations to locations where they have been extirpated would restore and protect an integral component of healthy high Sierra native ecosystems (Knapp et al. 2001).

Fourth, introduced trout not only contribute to the decline of MYLFs (Bradford et al. 1993, Knapp 1996, Vredenburg V., pers. comm., 2007), they contribute to a general loss of biodiversity in aquatic biota and associated terrestrial fauna. In the northern Sierra Nevada, the long-toed salamander appears to be found primarily in fishless lakes (Bradford and Gordon 1992). Epanchin (2010) found rosy-crowned finch to be more common at lakes without fish than at lakes with fish. This is because introduced fish populations limit mayfly populations on which the finch feeds during mayfly emergence. The mountain garter snake feeds on MYLFs. Matthews et al. (2002) found that mountain garter snake abundance is directly related to frog abundance.

While quantitative data is lacking, the abundance of other alpine/subalpine species are likely to be affected by losses of frog populations. Both Brewer's blackbirds and Clark's nutcrackers feed on MYLFs (Jennings and Hayes 1994, NPS unpublished data). While the high elevations of the southern Sierra Nevada seem to provide little natural food for black bears (Ursus americanus), they have been observed foraging for MYLFs (Knapp R., pers. comm., 2010). Before frog populations crashed, they may have been an important high elevation food for bears. Additionally, MYLFs are not only prey for a variety of alpine/subalpine vertebrates, they are also a predator. Much of their food is insects, but they feed also on small vertebrates, such as Pacific treefrogs (Pope 1999, Vredenburg V., pers. comm., 2007).

Trout virtually eliminate large-bodied invertebrates from lakes. When Stoddard (1987) surveyed zooplankton in 75 Sierra Nevada lakes, he found fish to be important predictors of species occurrence, with small-bodied species being found in association with fish and large-bodied species occurring only where fish are absent. Likewise, Bradford et al. (1994, 1998) found large-bodied planktonic microcrustaceans (e.g., Hesperodiaptomus shoshone and Daphnia middendorffiana) and epibenthic and limnetic macroinvertebrates (e.g., back swimmers, water boatmen, predaceous diving beetles, and larvae of some families of caddis flies and mayflies) to be relatively common in lakes without trout, but rare or absent in lakes with trout.

Herbst et al. (2009) found that the presence of introduced trout in streams resulted in decreased density for 20 invertebrate taxa and increased abundance for 6 taxa. The strongest effects appeared to be on taxa endemic to the Sierra Nevada, which had no coevolutionary history that would have facilitated their development of mechanisms to deal with fish predation. The study found that streams containing introduced trout had significantly more algae density and cover, increased abundance of midges, and reduced density of the most common large invertebrate predator, the stonefly Doroneuria baumanni.

Introduced trout are a threat to native trout, as well. On the Kern Plateau, introduced brown trout threatened the golden trout native to the South Fork Kern River. Programs to remove brown trout were necessary to manage the native fishery. In the Little Kern River drainage, the Little Kern golden trout became federally listed as threatened because of genetic introgression from planted rainbow trout. To this day there is an interagency effort to restore the Little Kern golden trout. Likewise, the original genotypes of rainbow trout native to the Parks western drainages are unlikely to have persisted following a century of planting non-indigenous rainbow and golden trout. Many of the fish in those streams show evidence of hybridization with golden trout.

The impacts of trout can be broader than the direct loss of the organisms they eat or displace. Those organisms are important components of the ecosystem. Once removed, their loss will affect the other native organisms on which they fed, as well as the creatures that depended on them for food. Knapp (1996) cites several published examples of these cascading effects.

Fifth, previously approved actions have been successful on a small scale in restoring the natural quality of wilderness character at treatment areas, including increasing MYLF populations and making them more resistant to the chytrid fungus, and in turn increasing other native species in the area that rely upon MYLF for prey or that are adversely affected by the presence of nonnative trout. A few MYLF populations are showing evidence of persistence – surviving and reproducing while continuing to be infected with chytrid fungus (Vredenburg et al. 2010; Knapp R., pers. comm., 2010). All persisting MYLF populations are in fishless areas and had high abundance prior to infection. Eradication of nonnative fish near existing MYLF populations would allow these populations to expand (Knapp et al. 2007) and should increase their resiliency to chytrid fungus by improving their ability to develop resistance to the disease before going extinct.

Finally, the continuing decline of MYLF and the high potential for the extinction of these species should no action be taken would result in a degradation to the high elevation ecosystems as previously described, and could potentially result in an impairment to park resources, because SEKI would lose a key natural component of the wilderness. Impairment is in direct conflict with NPS mandates.

In conclusion, action is necessary because native ecosystems (thus the natural quality of wilderness character) have been degraded from the presence of nonnative trout. The primary species affected are MYLFs, but there are cascading effects to other native species as well, as previously stated. MYLFs have disappeared from 92% of historic localities in the Sierra Nevada, including many localities in SEKI (Vredenburg et al. 2007) primarily due to the introduction of nonnative trout from 1870 to 1988 (a past trammeling action), while other populations remained strong in areas where fish were not introduced (Knapp and Matthews 2000). Recently, amphibian chytrid fungus invaded the Sierra Nevada and infected most of the MYLF populations in SEKI that were doing well in fishless areas (Vredenburg et al. 2010). Most of the infected populations severely declined, and some went extinct (NPS unpublished data). Those areas with the highest populations of frogs were able to withstand the outbreak of chytrid fungus.

SEKI is the only park that contains both species of MYLFs, making it ground zero and the most suitable place for their restoration and conservation. Without action, there is a high likelihood that the remaining populations of MYLFs in SEKI will go extinct, resulting in a permanent adverse effect on the natural quality of wilderness character; the NPS would not meet its conservation mandate, and impairment of high elevation ecosystems would occur. Because the proposed trammeling actions are highly likely to preserve the species, and allow the NPS to meet its mandate, trammeling actions and temporary developments are warranted in this situation.

If you are unable to determine if the action is necessary based on Step 1 information, consult your division chief/supervisor. Researchers consult the Research Permit Coordinator.

Compliance Pathway: Is the action covered under an existing plan, management directive and/or other compliance document (i.e., MD-49, EA, EIS, CE/programmatic CE).

Yes: ☐ **No:** ☒

If yes, provide document name and PEPC reference number:

The National Park Service had prepared a Draft High Elevation Aquatic Ecosystems Restoration Plan/draft environmental impact statement for this project (PEPC 17157).

If no, or you are unsure, contact the Environmental Protection Specialist for instructions.

STEP 2:
Determine the need to develop alternatives.

Does your project propose a Section 4(c) prohibited activity?

Section 4(c) prohibited activities include: the use of mechanical transport and/or motorized equipment and vehicles, the landing of aircraft, and the installation of materials, equipment and/or structures.

NOTE: *Installations include items used to support activities such as communications, water development, stock use, or wildlife management. It includes debris such as old dump sites, plane crash sites, or locations of unexploded ordinance. It includes memorials or other monuments other than those placed during land surveys. It also includes unattended measurement or other device(s) left in place for the purpose of recording environmental data or marking a study plot.*

Yes: ☒ **No:** ☐

If *yes*, proceed to Step 3.

Step 3: Determine the minimum activity.

Please refer to the instructions for additional information on developing alternatives and guidance on identifying effects.

Description of Alternatives

Develop a reasonable range of feasible alternatives. Include a list of alternatives that you considered and ruled out, and the justification for ruling out alternatives (alternatives should not be eliminated simply because of cost or the time involved). You should have at least two alternatives *plus* a "no action" alternative.

For each alternative, describe what the action is, when and where the activity will take place, and what methods and techniques will be used. Include estimates for frequency and duration of activities and actions.

When you are evaluating the effects from each alternative, detail the effects on the qualities of wilderness character and other comparison criteria, including safety. Where mitigation is possible, include mitigation measures. Add additional pages as necessary.

Alternative # __1___ No Action – Status Quo - Continue Current Project until Completed in 2016*

*Note: This alternative was previously evaluated in a 2001 Environmental Assessment and approved through a separate minimum requirement analysis.

Description:

Under the "No Action - Status Quo" alternative, the existing high elevation aquatic ecosystem restoration effort initiated in 2001 would be completed, maintained and monitored, but no new fish eradication activities would be initiated. Native species and ecological processes in high elevation aquatic ecosystems would continue to be monitored and conserved. Research on native species, ecological processes and their stressors would continue in accordance with NPS policy.

Restoration is conducted by NPS staff from the SEKI RMS division. Ongoing high elevation aquatic ecosystem restoration activities include habitat restoration in selected approved waters through removal of nonnative fish, experimental treatments of MYLF populations to mitigate effects of chytrid fungus infection, and experimental reintroductions of MYLFs into fishless waters.

From 1997 to 1999, researchers used gill nets to experimentally eradicate nonnative fish from two park waterbodies. This study showed that fish eradication was feasible (Vredenburg 2004). In February 2001, SEKI released an Environmental Assessment for Preliminary Restoration of Mountain Yellow-legged Frogs (NPS 2001). The document called for SEKI staff to eradicate nonnative fish from low- to moderate-use individual lakes and streams using gill nets and backpack electrofishers. The document was approved with a Finding of No Significant Impact in June 2001. This project has proceeded modestly in order to: 1) determine whether SEKI staff could eradicate fish from park waters, 2) measure benefits to MYLFs and 3) gain the knowledge needed to develop a comprehensive restoration program.

From 2001 to 2011, SEKI staff fully or nearly eradicated nonnative fish from 11 waterbodies (and associated streams); 8 were completed but 3 waterbodies had insufficient barriers (small non-vertical natural cascades) allowing fish to recolonize the treatment areas.

From 2009 to 2012, nonnative fish eradication was initiated in 13 additional waters. Eradications are complete in two of these waters (initiated in 2009), nearly complete in 6 of these waters (initiated in 2009), and in-progress in 5 of these waters (initiated in 2012). Active eradication work in all of these 13 waters is expected to be completed by 2016.

Under this alternative, monitoring and conservation of native species would continue into the foreseeable future in all 26 waterbodies.

Description of Physical Treatment Methods

<u>Gill Netting</u>
Gill netting is a method of fish collection that is primarily used in lakes, ponds and stream pools. Gill nets are considered an installation in wilderness which is a 4(c) prohibited action. The use of gill nets has been proven as an effective method for the removal of fish from small to medium lakes.

Repeated gill netting has been successfully used to completely remove fish from lakes (Knapp and Matthews 1998, Knapp et al. 2007, NPS 2012A). Gill nets are sinking nets designed to effectively capture fish of all sizes. Netting involves placing many sinking nets in a lake, with each net stretched from the shoreline out toward deep water at roughly equal distances between nets. Nets would be approximately 120 ft (36 m) long by 6 ft (1.8 m) deep, and have mesh sizes ranging from 0.4 inches (1 cm) to 1.5 inches (3.8 cm). Nets used to capture young fish that remain very close to shore, would be approximately 60 ft long by 6 ft (1.8 m) deep, and have mesh sizes ranging from 0.4 inches (1 cm) to 0.7 inches (1.7 cm). Gill nets would be deployed using inflatable non-motorized watercraft such as a float tubes, kayaks or rafts.

Nets would be set and pulled during daylight hours to minimize safety hazards and potential handling complications. When a new fish removal site is initiated, nets are frequently cleaned of captured fish and reset (generally every 24 to 48 hrs). By mid-season, capture rates decrease and the length of time that nets are set gradually increases. At the end of the summer field season, several nets are set in deeper water to continue catching fish under winter ice. Summer and over-winter netting continues until all nets set in a lake repeatedly capture zero fish. This method of gill netting typically results in the removal of all fish from a lake by the third or fourth summer, but could be extended to up to seven seasons depending on site conditions.

<u>Electrofishing</u>
Electrofishing is a physical method of fish collection primarily used in streams and occasionally in shallow water at the edges of lakes. Since it is not a mechanized or motorized equipment/use, electrofishing is not considered a 4(c) prohibited action. Electrofishing is a common fishery management technique that has been successfully used to collect fish for approximately 100 years (Cowx and Lamarque 1990). Electrofishing is implemented with a device called an electrofisher, which uses two electrodes to send electric current from a battery into the water. When both electrodes are submerged in the water and the unit is activated, the water completes the circuit and a field of electricity is generated around the electrodes. Fish caught in the field of electricity are stunned, float in the water and are captured using dip nets.

Battery-powered backpack electrofishers are the type of electrofishing units that would be used. A two to three person crew would be deployed, wearing chest waders, wading boots and rubber gloves. One person would operate the electrofisher while the remaining crewmembers would stand on either side of the operator and capture shocked fish using dipnets. Each stream electrofishing session would begin at the downstream boundary of the targeted stream segment and proceed in an upstream direction. This allows stunned fish to drift downstream toward crews and dip nets. Fish removal by electrofishing requires repeated passes through each target stream section until all fish have been eradicated.

<u>Disruption or Covering of Redds</u>
Where redds (fish egg nests) are visible in gravel-bottom areas of streams and shallow lakeshores, they would be disrupted with a shovel or by foot to minimize hatching of fish eggs. Gravel in these areas would then be covered with boulders to eliminate or minimize future fish reproduction in these areas. The disruption of covering of redds is not a 4(c) prohibited action and is moderately successful at removing fish on a small scale.

<u>Fish Traps</u>
Fish traps may be used to augment gill netting and electrofishing efforts when necessary to maintain fish free conditions. If fish traps are used, they would be set in lake inlets and/or outlets to catch fish as they leave the lake to spawn. Fish traps are considered an installation in wilderness which is a 4(c) prohibited action. Fish traps are moderately successful in capturing fish.

During the first field season, traps would be set during ice-out and removed in the fall. Following the first field season, the effectiveness of having the traps deployed throughout the entire ice-free season would be assessed. If the traps were not effective outside of the spring spawning season, than traps would only be deployed during the spring in subsequent years, otherwise, the traps would be deployed throughout the ice-free season until the site was restored. If the inlet or outlet stream is wider than the trap (1.6 ft / 0.5 m) than mesh arms made out of PVC pipe and aquaculture mesh would be used to construct a funnel between the trap and the stream bank.

Components of the Action		**Activity for this Alternative**
1	Transportation of Personnel to and from the Project Site	Crews hike to and from project sites.
2	Transportation of Equipment to and from the Project Site	Equipment is transported by helicopter or stock* (see conditions that warrant the use of helicopter). Stock would be used for mobilizations and demobilizations of physical treatment sites. Stock would be used for two round trips per site, 1 to 2

		sites per year. In general, site mobilizations require 5 animals and demobilizations require 3 to 4 animals plus a packer and riding stock. The maximum yearly stock use is estimated to be 8 to 9 animals per site, requiring only one overnight stay per trip. Therefore, the maximum expected stock nights (number of animals multiplied by nights) per year generated by any of the project alternatives are estimated at 16 to 18 nights. • Mobilization: a total of 3-5 flights and 0-2 packstock trips (one mobilization per area) • Demobilization: a total of 3-5 flights and 0-2 packstock trips (one demobilization per area)
3	Establishment of and Use of Crew Camps	Crew size is typically 2 to 3 crewmembers. Crews would camp up to 10 days per site visit and each site would be visited up to 7 times per season. Physical restoration generally takes 6 years per lake and up to 10 years per stream and marsh area. Crew camps include a short-term installation of a food and equipment storage locker which would be left in place for the duration of the project work, and removed once the project work is completed.
4	Fish Capture Techniques and Tools	Crews utilize gill nets, fish traps, and battery-powered electrofishers to complete work.
5	Translocation Methods	Frogs to be translocated are either hiked to nearby recipient habitat or transported by helicopter to distant recipient habitat. ‘Nearby’ habitat generally can be hiked to within 6 hours, posing minor risk to frog survival during transport. ‘Distant’ habitat cannot be hiked to within 6 hours, which would pose moderate to high risk to frog survival during transport. At the recipient site, all individuals would be released into fishless habitat and monitored for the next several years.
6	Stream barriers	There would be no stream barriers constructed or placed in the streams under this alternative.
7	Condition of Site After Project	Natural conditions would be restored in 26 waterbodies.

*Stock is currently the preferred transport method used to support this project except when one of the following conditions applies:

- Equipment is fragile.
- Cargo is time-dependent or requires stable conditions.
- Cargo is bulky and does not fit well on or over panniers.
- An individual piece of cargo weighs over 150 pounds.
- Stock is not allowed in the area, a waiver for stock use is not authorized by the superintendent, or the area is inaccessible to stock.
- Stock would create unacceptable environmental impacts due to wet trail conditions, and it is impractical to reschedule stock use for a less damaging time.
- Use of stock would cause more environmental impact than a helicopter because the area can only be accessed off trail, or the site is vulnerable to adverse effects.

- Environmental hazards to personnel or animals (e.g., snow or high water crossings) create unsafe conditions for stock use and transport of the material cannot wait until conditions improve.

Exact dates of flights and stock trips could change by 1 to 2 days due to respective Helitack and packer schedules, weather, and/or emergencies at that time.

Actions would continue for the five aquatic ecosystem restoration areas until they are completed. The remaining restoration areas include:

Sixty Lake Basin A crew of two biological technicians would work full-time in Sixty Lake Basin from mid June to mid September. During mobilization in early summer, trail conditions (snow, water and logs on trails) make stock use unfeasible and inappropriate. To demobilize Sixty Lake Basin by stock, trail access would be via an unmaintained route. However, stock use in Sixty Lake Basin is prohibited past a certain point to protect fragile amphibian breeding habitat. The camp for the restoration crew is within the stock prohibition area, about one-half mile past the prohibition point. This camp needs to be mobilized and demobilized by a helicopter because the camp is in a stock prohibited area. Work involves restoring six lakes with a full-time crew that needs to mobilize ~800 Ibs of food/gear per summer using 1 helicopter mobilization flight and 1 helicopter demobilization flight.

Amphitheatre and Pinchot Basins A crew of two biological technicians would work partly in Amphitheatre Basin and partly in Pinchot Basin. Amphitheatre Basin would be worked from early July to mid September - mobilized/demobilized by helicopter. The camp is 2 miles from trail and 2,000 feet higher with a rugged approach not feasible by packstock. Work involves restoring two lakes and two ponds with a part-time crew that needs to mobilize ~600 Ibs of food/gear per summer using 1 helicopter mobilization flight and 1 helicopter demobilization flight.

Pinchot Basin would be worked from mid July to late September. The camp would be located at the Bench Lake Ranger Station, which could be mobilized/demobilized by either packstock or helicopter. Work involves restoring one lake with a part-time crew that needs to mobilize ~400 Ibs of food/gear each summer using 1 helicopter or packstock mobilization (packstock would be 1 packer/horse and 3-4 mules). A helicopter would be used if there is too much snow in the area, preventing packstock from being able to access this area. The demobilization would involve 1 packstock trip, containing 1 packer/horse and 2-3 mules.

Kern Point and Center Basins
A crew of two biological technicians would work partly in Kern Point Basin and partly in Center Basin. Kern Point Basin would be worked from early July to mid September. The camp is 1.5 miles from trail and 2,300 feet higher with a rugged approach not feasible by packstock. Work involves restoring two lakes with a part-time crew that needs to mobilize ~500 Ibs of food/gear each summer using 1 mobilization flight and 1 demobilization flight.

Center Basin would be worked from mid July to late September. The Center Basin camp would be mobilized/demobilized with a combination of packstock and helicopter. The camp is in gentle terrain near a trail area where day packstock use is allowed. Work involves restoring one lake with a part-time crew that needs to mobilize ~400 Ibs of food/gear each summer using 1 mobilization flight or stock trip (packstock would be 1 packer/horse and 3-4 mules). A helicopter would be used if there is too much snow in the area, preventing packstock from being able to access this area. If a helicopter is used, and timing coincides with a separate project involving transport of materials needed to mitigate/study an expected frog die-off in the Center Basin area, then the mitigation/study materials would be transported within this restoration flight, thereby eliminating the need for an additional flight in wilderness. The demobilization would involve 1 packstock trip, containing 1 packer/horse and 2-3 mules.

Effects to Wilderness Character:

Untrammeled. The removal of fish is a trammeling action. Also, translocating frogs into currently unoccupied habitat is a trammeling action. Both would occur at the remaining project sites until site restoration is completed in 2016.

Undeveloped. The project crew camps have a short-term adverse effect on the undeveloped quality of wilderness. The use of helicopters for the transport of materials and the translocation of frogs has a short-term effect on the undeveloped quality. The use of gill nets is an installation – and netting would continue through 2016 at project sites. Some nets remain in place over the winter months; all are removed after project activities are completed. The small crew camps could have food storage lockers in place for several years, and would be a temporary development in wilderness. However, there would be no permanent change to the undeveloped quality of wilderness under the no action alternative as all developments would be removed after the project completion in 2016.

Natural. The natural ecosystem would be restored in 26 park waterbodies, totaling less than 5% of the 575 waterbodies that contained nonnative fish prior to the start of research-led eradications in 1999 and park-led eradications in 2001. However, the remaining high elevation waterbodies that contain self-sustaining nonnative trout populations (549 waterbodies plus connecting streams contained in 88 basins) would not be managed so as to preserve their natural condition and nonnative fish would likely remain into the foreseeable future, adversely affecting the natural quality of wilderness. As a consequence of the presence of nonnative fish, there has been an extensive loss of native fauna and the proliferation of nonnative fauna. Invertebrate communities have been changed by introduced fish, including a loss of some large species. Some algae communities have been changed from altered invertebrate and vertebrate communities. Mountain yellow-legged frogs are declining and are at risk of extinction due to loss of habitat from introduced fish, infection by chytrid fungus, climate change, and possibly effects from contaminants that originate from outside the parks. Gray-crowned rosy finch has significantly less use of lakes that have nonnative fish due to reduced hatch of mayflies and bat species are likely experiencing a similar impact. The impacts on the natural quality of wilderness have been and will continue to be long-term and adverse.

Solitude or Primitive and Unconfined Recreation. The presence of small work crews and equipment could have a negative effect on solitude. However, the work crews are generally small and very similar in appearance to a wilderness visitor's campsite. Also, crews generally camp away from popular camping spots, and most of the work is located away from the primary visitor use areas.

Other Features of Value. N/A

Effects to safety: Helicopter operations are inherently risky. Prior to considering whether to use helicopters, the previous criteria are considered. An experienced crew would be utilized for helicopter operations. Appropriate training would be provided to all staff working around helicopters.

Effects to other criteria (e.g., special provisions, economics, timing constraints, traditional skills, weather, visitation, etc.): Time of year and weather are considerations when planning project activities, and are considered when determining if a helicopter or stock crew would be utilized to transport equipment to the project site. If it is not possible to use stock to access a camp location due to snow conditions, then a helicopter would be considered for mobilization/ demobilization.

Elements Common to All Action Alternatives:

The following are components of all of the proposed action alternatives that would occur under any of the alternatives. Under each alternative, there would be crew camps established for the project duration. The duration and size of the camp would depend on the alternative selected. Under each alternative, there would be continued ecosystem restoration activities, which would include rebuilding existing populations of MYLFs by reintroducing them into areas previously occupied by frogs, or where nonnative fish removals would be accomplished. Under each alternative, research and monitoring would continue to occur into the future as funding allows. And under each alternative, there would be fish captured and disposed. These elements are evaluated in the following section.

Crew Camps: Crew camps would be required for each selected project area. Crew camps are necessary because the project sites are far from trailheads and this necessitates crews being stationed in the field at project locations for the duration of the project work.

Crew camps are similar in size and scale to a wilderness backpacker camp. Crew members bring individual tents and there could be one larger tent used as a work or cooking area. The primary differences between alternatives are the size of the crew, the duration of use and the placement of equipment and/or food storage lockers. Also either a latrine would be dug at the camp, or a portable toilet would be utilized (depending on the location, soil conditions, and site sensitivity).

Food storage and equipment lockers are necessary because a large amount of food is brought into the wilderness for the duration of the project work, more than can be contained in personal portable food storage containers. It is important to protect wildlife from obtaining food from humans. In addition, due to the high elevation of most areas, there are not trees large enough to hang food. Equipment storage is necessary to protect fragile equipment from the weather and site conditions.

Crew camps would be used yearly until the project work is accomplished. Crew camps could be in place up to 10 years per site for physical treatment sites, and 1 to 2 years per site for piscicide treatment sites. Depending on the alternative selected, there could be 1 to 6 crews working at different restoration areas from June or July through September.

Effects of Crew Camps on Untrammeled: There is no manipulation of the wilderness from the presence and use of crew camps. Therefore there is no effect on the untrammeled quality of wilderness.

Effects of Crew Camps on Natural: The effect on the natural quality of wilderness from the presence of crew camps is slight. Small crews staying in one location for several weeks will have an impact on soils in a localized area from trails and compaction around the camp and project area, and could trample vegetation. There could be displacement of wildlife at the camp location, and disturbance from the presence of humans. Crews would be instructed on minimum impact techniques to reduce effects on the natural quality, and would be instructed to avoid areas with sensitive plants. Post project mitigation to rehabilitate the area would be considered and accomplished if warranted.

Effects of Crew Camps on Undeveloped: There would be short- term adverse effects on the undeveloped quality of wilderness from the presence of crew camps and associated supplies and transport of supplies. Gear and camping equipment is evident at crew camps. While camping equipment and personal gear is removed at the end of each project or each season, some gear is cached at the camp location in secure equipment containers/lockers for the duration of the project. This results in adverse effects on the undeveloped quality of wilderness character at each project location. However, this effect is not permanent and lasts only for the duration of treatment at each site (2 weeks to 10 years depending on the site and treatment method).

Effects of Crew Camps on Opportunities for Solitude or Primitive and Unconfined Recreation: The presence of crew camps in several locations in the wilderness would reduce opportunities for solitude in the project areas. It is unlikely but still possible that wilderness users could see the crews and/or their camps though the camps would generally be located away from popular trails and destinations and would be sited in areas of low visibility, therefore, the adverse effects would not be noticeable to the average wilderness visitor and short- to long-term (depending on the treatment type selected).

Effects of Crew Camps on Other Features of Value: There is no effect on other features of value from the presence and use of crew camps.

Ecosystem Restoration: The large loss of MYLFs in the Sierra Nevada including the parks has heavily fragmented the populations that remain. Areas in which MYLF populations have disappeared are likely too far from existing populations to be naturally recolonized by migrating frogs. If unaddressed, this situation would make MYLFs much more vulnerable to further losses. The only tool available at this time to reestablish MYLFs in currently vacant, previously occupied basins is to move animals from source populations to these areas (Brown et al. in preparation).

Two critical elements of high elevation aquatic ecosystem restoration would include 1) protecting and rebuilding extant populations of MYLFs where opportunities still exist, and 2) reintroducing MYLFs to locations where populations have recently gone extinct. Nonnative fish removal would be a primary step in attempting to restore [a viable, sustainable population of] MYLFs, other native species and natural function to high elevation aquatic ecosystems.

All waters identified for fish eradication would be considered potential reintroduction sites. Reintroductions would be based on the best science available and the protocol would be developed in collaboration with other federal and state agencies (e.g., FWS, USFS, USGS, and CDFW) and academic researchers. The approach to reintroductions, including preserving genetic diversity, treating frogs for chytrid fungus, and identifying source populations, would be developed with guidance from the “Mountain Yellow-legged Frog Conservation Strategy.”

To mitigate the extensive losses of MYLFs populations, a number of individuals would be moved from extant populations to areas where populations recently died out or severely declined. Movement would involve 1) capturing a small percentage (typically <10%) of the individuals in a source population using dipnets; 2) measuring the body condition of each animal (length, weight, sex, chytrid level); 3) inserting a passive integrated transponder (PIT) tag under the skin of each frog larger than 1.25 inches long from snout-to-vent (Matthews and Preisler 2010) to monitor the status of each animal following reintroductions; 4) placing them in aerated containers of water; 5) potentially treating frogs prior to translocation with antifungal drug (e.g., Itraconazole); 6) potentially bioaugmenting naturally occurring bacteria (Janthinobacterium lividum) on frogs; and 7) either hiking them to nearby recipient habitat or transporting them by helicopter to distant recipient habitat.

If determined necessary, MYLFs may be treated with Itraconazole prior to their reintroduction. The treatments would likely occur at the source site. Under current methods, frogs would be held for 7 days in mesh cages (2 m x 2 m x 0.5 m) anchored in the lake. The frogs would be treated once a day by moving them into plastic tubs containing a dilute Itraconazole solution. Animals would be bathed in the treatment solution for 10 minutes per day and then returned to the cages. After 7 days of treatment, animals would be transported to the receiving lake where they could be treated with a bioaugmentation of J. lividum that was collected from the source population and cultured in the laboratory. Under current methods, frogs would be held for 2 days in mesh cages (2 m x 2 m x 0.5 m) anchored in the lake. The frogs would be treated once a day. Up to 15 frogs would be placed in 1 liter plastic containers that contain a concentrated solution of J. lividum mixed with lake water. Animals would be kept in the solution for 1 hour per day for two days and then returned to the cages. The frogs would be released into the receiving lake after the second day of treatment.

‘Nearby’ habitat generally can be hiked to within 6 hours, posing minor risk to frog survival during transport. ‘Distant’ habitat cannot be hiked to within 6 hours, which would pose moderate to high risk to frog survival during transport. At the recipient site, all individuals would be released into fishless habitat and monitored for the next several years.

Effects of Restoration of Mountain Yellow-Legged Frogs on Untrammeled: Where reintroductions are used and experimental treatments to species occurs (e.g. antifungal treatments), there would be short-term adverse impacts on the untrammeled element of wilderness character since there would be an intentional manipulation of a native species in the wilderness. The effects on untrammeled occur only for the duration of restoration activities, resulting in short-term adverse effects on untrammeled; however, these activities could occur periodically for the life of the project (25 to 35 years)), so at any given time on a landscape /wilderness scale there would be trammeling actions occurring related to these activities.

Effects of Restoration of Mountain Yellow-Legged Frogs on Natural: Restoration of key species (MYLFs) would allow invertebrate, frog, and other wildlife populations to recover to conditions representative of conditions where nonnative fish are not present. There would be short-term adverse effects on the source populations resulting from the removal of a small percentage of MYLFs for reintroductions (in general, no more than 10% of the adult population would be removed for a reintroduction). Based on results from previous reintroductions in YOSE, the source population should rebound quickly; previous removal of approximately 20% of the adult frogs from a source population resulted in a large pulse of recruitment in subsequent years that compensated for the removals. If ecosystem restoration is successful, there would be long-term beneficial effects on the natural element of wilderness character by restoring two species of concern and thus improving the overall health of the high elevation aquatic ecosystems.

Effects of Restoration of Mountain Yellow-Legged Frogs on Undeveloped: Similar to the crew camps for the proposed restoration work, there are crew camps associated with ecosystem restoration activities. Crews would stay in backpacker-like camps and would follow minimum impact wilderness practices. The duration of these camps would range from a few days to the entire summer. No equipment of gear would be left on site over the winter. Helicopter and stock may be utilized to deliver gear and supplies to the camps and for restoration purposes if timing is an issue (i.e. moving tadpoles and/or frogs from one site to another quickly) and if determined to be the minimum tool for the project. The effect on undeveloped would be adverse, short- and long-term.

Effects of Restoration of Mountain Yellow-Legged Frogs on Opportunities for Solitude or Primitive and Unconfined Recreation: There would be short- and long-term adverse effects on solitude from the presence of crews in the wilderness over the duration of the restoration project. As described under “Effects from Crew Camps” it is unlikely but still possible that wilderness users could see the crews and/or their camps though the camps would generally be located away from popular trails and destinations. Generally these crews are small and the average wilderness visitor can not differentiate these crews from other wilderness users.

There would be long-term, adverse effects on opportunities for primitive and unconfined recreation resulting from the localized loss of angling opportunities in up to 87 waterbodies contained in up to 20 basins. However, there could be long-term beneficial effects on primitive recreation related to viewing native wildlife and healthy native ecosystems.

Effects of Restoration of Mountain Yellow-Legged Frogs on Other Features of Value: This project component would benefit Other Features of Value, particularly the scientific, ecological, and education components.

<u>Research and Monitoring:</u> Scientific research is one of the purposes of wilderness. Monitoring is considered part of research. Research is conducted by staff and scientists from public agencies and academic and independent institutions, as managed through SEKI’s research permit process. Research findings are written into reports and/or peer-reviewed publications that are used to inform park management and help with decision-making.

Monitoring is conducted by NPS staff from the SEKI Resource Management and Science (RMS) division and the Sierra Nevada Network Inventory and Monitoring program, and by scientists in association with permitted research. High elevation aquatic ecosystem components that are currently monitored include water quality, and populations of amphibian and reptiles associated with restoration and research sites. Any research or monitoring projects that propose 4(c) actions would be evaluated separately.

Effects of Monitoring and Continuing Research on Untrammeled: While most monitoring and research activities do not result in an intentional manipulation of natural elements, there are exceptions. Treating wildlife with antifungal drugs and supplementing their immune defenses with naturally co-occurring bacteria are examples of activities that result in a trammel. The effects on untrammeled occur only for the duration of project activities, resulting in short-term adverse effects on untrammeled; however, these activities could occur periodically for the life of the project (25 to 35 years), so at any given time on a landscape scale there would be trammeling actions occurring related to these activities.

Effects of Monitoring and Continuing Research on Natural: Research would have a short-term adverse effect on the natural quality of wilderness character from the use of antifungal treatments, bioaugmentations, and the removal of individuals from populations. However, in the future, as more information is gained through these programs, there would be long-term beneficial effects on the natural qualities of wilderness as ecosystem restoration is accomplished.

Effects of Monitoring and Continuing Research on Undeveloped: Monitoring would include sampling for invertebrates, and could include the use of samplers and drift nets. These activities require temporary installations, which would result in adverse effects on the undeveloped quality of wilderness in localized areas for the duration of the project work. Antifungal treatments and supplementing naturally occurring bacteria would involve holding animals in small cages for a period of time (currently 8 days). Helicopter and stock may be utilized to deliver gear and supplies to the project site if determined to be the minimum tool for the project. Helicopter use has an adverse effect on undeveloped. The effects on undeveloped would be adverse and short-term at specific project locations, but these effects would occur periodically for the life of the project (25-35 years) resulting in long-term adverse effects.

Effects of Monitoring and Continuing Research on Opportunities for Solitude or Primitive and Unconfined Recreation: Monitoring and research generally involves 2-3 people per project. As stated under “Effects from Crew Camps” the presence of researchers and monitors reduces opportunities for solitude in the project areas during project activities. Monitoring and research can occur throughout the high elevation wilderness of the parks, but generally occur away from the primary visitor use areas. Crews are small and no different in appearance than the average wilderness user group. If helicopters are utilized, there would be an effect on solitude as the natural soundscapes would be disrupted. Therefore the impact on solitude is short-term and adverse. Research and monitoring would lead to improved management of natural resources and restoration of native species; therefore, there would be long-term beneficial effects on primitive recreation related to viewing native wildlife and healthy native ecosystems.

Effects of Monitoring and Continuing Research on Other Features of Value: This project component would benefit Other Features of Value, particularly the scientific and education components.

<u>Fish Capture and Disposal:</u> The primary method proven to achieve ecosystem restoration is the removal of nonnative fish from selected waterbodies. With no fish removal, the ecosystems would not be restored, and native species would not be protected. Therefore, the removal of nonnative fish would occur under all alternatives; however, several alternative removal methods are considered within specific alternatives.

For all fish removal activities, removed fish would accumulate and require disposal. Crews would either puncture the bladders of all fish captured (to prevent them from floating) and sink them in deep water to the bottom of each restoration lake, or crews would dispose fish by scattering them in nearby terrestrial areas away from trails and campsites.

Effects of Fish Disposal on Untrammeled: The disposal of fish is not an intentional manipulation of the natural element, but is a result of a manipulation (i.e. the removal of nonnative fish from waterbodies). Therefore there would be no effect on untrammeled as a result of the disposal of fish.

Effects of Fish Disposal on Natural: If dead fish are disposed of by puncturing their bladders and sinking them in deep water there would be a short-term effect on the natural quality of wilderness as a result of adding nutrients to the system until the fish biodegrade. There would be short-term adverse impacts to water quality, but the nutrients would ultimately be cycled back into the ecosystem where they originated resulting in a long-term beneficial effect. If fish are scattered in the project area, there could be a short-term effect on the natural quality by providing an otherwise non attainable food source to area scavengers and native wildlife.

Effects of Fish Disposal on Undeveloped: There would be no effects on undeveloped as a result of fish disposal actions.

Effects of Fish Disposal on Opportunities for Solitude or Primitive and Unconfined Recreation: Fish would be scattered away from trails and camp areas resulting in no effect on solitude or primitive and unconfined recreation.

Effects of Fish Disposal on Other Features of Value: There is no effect.

Effects to safety from Elements Common to All Alternatives: There are no effects to safety out of the ordinary. All project work would require the preparation of Job Hazard Analyses.

Effects to other criteria from Elements Common to All Alternatives (e.g., special provisions, economics, timing constraints, traditional skills, weather, visitation, etc.): Actions would need to occur during summer months to allow for travel into the SEKI wilderness when conditions are suitable (little or no snow and ice).

Components of the Action Alternatives

Under each action alternative, the following project components are considered in addition to the elements common to all action alternatives. Components and project elements that have been considered but ruled out are included in the “Alternatives Considered but Dismissed” section of this MRA.

Project Component	Description
Component 1	Transportation of Personnel to the Project Site
Component 2	Transportation of Equipment to the Project Site
Component 3	Establishment of Crew Camps
Component 4	Fish Capture Techniques
Component 5	Translocation Methods
Component 6	Stream barriers
Component 7	Condition of Site After Project

Alternative # __2___ Physical and Piscicide Treatment Preceding Restoration – 4(c) activities – use of gill nets, fish traps, temporary fish barriers, and crew camps (installations); Use of stock and helicopters.

Description:

Both physical (use of gill nets, electrofishers, covering redds, and use of fish traps) and piscicide treatment methods (use of rotenone) would be used for nonnative fish eradication. Waters determined infeasible for physical treatment (see below criteria) would be restored using piscicides.

Basin prescriptions would be developed during years immediately prior to treatment so that information would be current when the treatment begins. The precise areas to be treated by different methods (physical or piscicide) would be developed following a thorough survey of each site. Information needed to develop each prescription would include precise information on the distribution of fish and amphibians, potential need for and proposed location of fish barriers, invertebrate surveys, habitat characteristics (open water, aquatic and riparian vegetation), and basin characteristics (stream flow/gradients, lake size/depth, channel characteristics, connectivity between sites, and unique aquatic environments).

Under alternative 2, physical treatment would be the preferred method. Piscicide treatment would be used if: 1) a lake is too large or lacks adequate shoreline; 2) a stream is too long, steep, or marshy or has other characteristics that would make physical treatment ineffective for fish eradication; 3) implementation of physical treatment pose an unacceptable safety risk to field crews; or 4) the selected waterbodies exist in basin complexes that lack natural barriers between most of the individual lakes or are too extensive for physical treatment. The waterbodies proposed for piscicide treatment also include a few small sites located on marshy stream reaches where it would be infeasible to exclude a waterbody from the reach.

In addition, piscicide treatment would be the preferred treatment method in a situation where time was critical for preventing the impending extinction of a MYLF population. Waterbodies that would provide more value in the face of climate change would be considered for piscicide applications (i.e. large, deep, and/or cold waterbodies that can buffer drying and warming trends). Pre- and post-treatment monitoring of the habitat and invertebrate and vertebrate populations would be a component of the use of piscicides.

Based on current knowledge of the proposed fish eradication sites, physical treatment would be used for 49 waterbodies (26 lakes, 22 ponds, 1 marsh; total of 483 acres) and approximately 14 miles of streams in 15 basins; piscicide treatment would be used for 38 waters (6 lakes, 28 ponds, and 4 marshes; total of 225 acres) and approximately 27 miles of stream in 11 basins. In addition, any fish-containing habitat adjacent to treated lakes, ponds and streams identified during fieldwork would also require treatment in order to eradicate fish from each restoration area. These are generally small areas that are not captured in existing maps of proposed project areas. Although the total acreage requiring treatment may change slightly based on site-specific survey information and prescription development, the number of waters and stream miles identified for treatment represents the maximum number of waters to be treated in this alternative, and may be reduced as basin prescriptions are completed.

The physical treatment methods of gill netting, electrofishing, covering redds, and using fish traps are the same as those described under Alternative 1.

For areas where piscicide treatment is proposed, temporary fish barriers (using nets or screens) would be placed in areas where barriers to fish movement are not present. These barriers serve to prevent fish from moving from an untreated area into a treated area. These temporary fish barriers can be used for the piscicide treatment method because treatment can occur quickly in all connected waters. Therefore they only need to be in place until treatment activities are completed.

Stock would be the preferred transport method used to support this project except when one of the following conditions applies:

- Equipment is fragile.
- Cargo is time-dependent or requires stable conditions.
- Cargo is bulky and does not fit well on or over panniers.
- An individual piece of cargo weighs over 150 pounds.
- Stock is not allowed in the area, a waiver for stock use is not authorized by the superintendent, or the area is inaccessible to stock.
- Stock would create unacceptable environmental impacts due to wet trail conditions, and it is impractical to reschedule stock use for a less damaging time.
- Use of stock would cause more environmental impact than a helicopter because the area can only be accessed off trail, or the site is vulnerable to adverse effects.
- Environmental hazards to personnel or animals (e.g., snow or high water crossings) create unsafe conditions for stock use and transport of the material cannot wait until conditions improve.

Location of Proposed Treatments

Aquatic ecosystem restoration would take place in 41 basins. Nonnative fish would be eradicated from selected waterbodies in 20 basins, including 82 lakes and ponds (676 ac), 5 fish-containing marshes (32 ac), approximately 41 miles of stream, plus additional connected fish-containing habitat if necessary. These 87 waters represent 16% of the parks' 549 waters known to contain nonnative fish that are candidates for eradication. While the goal of this alternative would be to restore 41 basins over the life of the project (25-35 years), some basins would not be restored because of access limitations to some of the areas.

Basin	# Lakes	Area (ac)	# Ponds	Area (ac)	Stream (mi)
Physical Treatment					
Barrett	3	43.37	1	0.24	0.44
Blossom	2	9.98	2	2.05	1.01
Brewer	0	0	1	2.18	0.49
Crytes	2	20.62	1	0.87	0.02
Dusy	1	10.58	2	0.60	0.69
East Wright	1	2.63	0	0	0.66
Horseshoe	4	27.26	0	0	0.93
McGee	4	75.31	4	1.19	0.99
Milestone	1	12.80	1	2.07	0.49
Rambaud	0	0	1	0.38	0.79
Tablelands	0	0	1	1.37	1.48
Upper Bubbs	2	21.12	2	1.48	3.68
Upper Evolution	4	228.19	1	0.48	1.46
Upper Kern	0	0	2	2.12	0.38
Vidette	2	14.66	3	0.20	0.44
Subtotal Physical	**26**	**466.51**	**22**	**15.23**	**13.94**
Piscicide Treatment					
Amphitheater	1	58.87	2	1.34	2.16
Barrett	0	0	0	0	2.66
Crescent	0	0	0	0	3.98
Crytes	0	0	0	0	3.38
Laurel	0	0	1	0.22	4.98
Sixty Lake	1	12.94	16	14.56	1.84
Slide	1	5.12	0	0.00	4.13
Tablelands	1	76.77	1	1.57	0.76
Upper Bubbs	0	0	0	0	0.81
Upper Evolution	0	0	0	0	0.72
Upper Kern	2	18.32	8	4.17	1.47
Subtotal Piscicide	**6**	**172.02**	**28**	**21.87**	**26.87**
Grand Total	**32**	**638.53**	**50**	**37.10**	**40.81**

Components of the Action		**Activity for this Alternative**
1	Transportation of Personnel to and from the Project Site	Crews hike to and from project sites.
2	Transportation of Equipment to and from the Project Site	Stock would be used for mobilizations and demobilizations of treatment sites unless conditions warrant the use of helicopters (see conditions described above). Stock would be used for two round trips per site, 1 to 2 sites per year. In general, site mobilizations

		require 5 animals and demobilizations require 3 to 4 animals. The maximum yearly stock use is estimated to be 8 to 9 animals per site, requiring only one overnight stay per trip. Therefore, the maximum number of expected stock nights (number of animals multiplied by nights) per year generated by any of the project alternatives is estimated at 16 to 18 nights. Where stock cannot access sites due to steep terrain or unsuitable/closed trails, work crews would be used to walk-in equipment from the stock drop off point. For heavy or bulky equipment, or when special conditions apply, helicopters would be used to transport materials to the project site. There could be up to three flights per restoration site per year. Flights would occur at mobilization to deliver supplies, and at demobilization to remove supplies and materials from the project site. Flights would be of short duration and would only be used if stock could not be used to transport supplies to a given project site.
3	Establishment of and Use of Crew Camps	Crew size would be 2 to 3 crewmembers at physical treatment sites, and these crews would camp up to 10 days per site visit and each site would be visited up to 7 times per season. Crew size would be 8 to 15 crewmembers at piscicide worksites. Restoration using piscicides would be expected to take 2 to 4 weeks in each of 1 to 2 years per site. Crew camps include a short-term installation of a food and equipment storage locker which would be left in place for the duration of the project work, and removed once the project work is completed.
4	Fish Capture Techniques and Tools	Gill netting, fish traps, electrofishers, disruption of redds, and piscicides (including a small electric pump)
5	Translocation Methods	Frogs to be translocated are either hiked to nearby recipient habitat or transported by helicopter to distant recipient habitat. ‘Nearby’ habitat generally can be hiked to within 6 hours, posing minor risk to frog survival during transport. ‘Distant’ habitat cannot be hiked to within 6 hours, which would pose moderate to high risk to frog survival during transport. At the recipient site, all individuals would be released into fishless habitat and monitored for the next several years.
6	Stream barriers	There may be temporary stream barriers placed in the waters under this alternative. Temporary fish barriers would be installed if needed to protect an invertebrate source population from fish recolonization until fish are eradicated with piscicides. This would include installing temporary

		nets or screens within streams to prevent fish from swimming upstream. No permanent fish barriers would be installed or created by blasting instream rock.
7	Condition of Site After Project	Aquatic ecosystem restoration would take place in up to 41 basins. Nonnative fish would be eradicated from selected waterbodies in 20 basins, including 82 lakes and ponds (676 ac), 5 fish-containing marshes (32 ac), approximately 41 miles of stream, plus additional connected fish-containing habitat if necessary. These 87 waters represent 16% of the parks' 549 waters known to contain nonnative fish that are candidates for eradication. Invertebrates would be eliminated at the piscicide treatment sites until recovery occurs. The recovery of invertebrates (thus the restoration of the natural quality) at the treatment sites could take 5 years or more (Mangum and Madrigal 1999). There would still be self-sustaining nonnative trout populations present in approximately 462 waters plus connecting streams.

Effects to Wilderness Character:

Untrammeled: The project itself constitutes a long-term trammel as it would continue for the next 25 to 35 years across identified areas in the parks' wilderness. There would be site-specific trammeling at up to six treatment sites per year, for several weeks each summer, over a 1 to 7 year period, with some sites treated for up to 10 years.

Under this alternative, there would be short- and long-term adverse effects as a result of trammeling due to the physical and piscicide treatments to remove nonnative fish, netting streams to prevent nonnative fish movement between treated and untreated areas, and pre- and post invertebrate sampling, which involves the collection of invertebrates from piscicide treatment areas, all of which are intentional manipulations of the wilderness.

Over the life of the project, physical treatment would be used for 49 waterbodies (26 lakes, 22 ponds, 1 marsh; total of 483 acres) and approximately 14 miles (22 km) of streams in 15 basins; piscicide treatment would be used for 38 waterbodies (6 lakes, 28 ponds, 4 marshes; total of 225 acres) and approximately 27 miles (44 km) of streams in 11 basins. In addition, any fish-containing habitat connected to treated lakes, ponds and stream sections identified during fieldwork would also require treatment in order to eradicate nonnative fish from each restoration area.

For sites that are too large or lack adequate shoreline access, for selected stream channels, where physical treatment has been unsuccessful, or where there is an unacceptable risk to field crews, piscicide treatment would be employed, occurring over 1 to 2 years at each site. Active work by crews would occur primarily during the summer (up to 10 days per site up to 7 times a season). Passive winter netting (i.e. leaving the nets under ice in waterbodies over winter months without the presence of crews) would continue to result in the removal of nonnative fish.

The primary differences between physical and piscicide treatment methods as it relates to the effects on untrammeled is the time it takes to treat a waterbody, and the intensity of the effort. Physical treatment would result in an ongoing trammel of up to 10 years per treatment site, whereas piscicide treatment would result in a trammel for up to 2 years per treatment site. However, with piscicide treatment, many more individual nonnative fish are killed in a shorter period of time, and non-target species are also affected and may be killed. These effects are described in detail under the following “Natural” section.

Natural: Under this alternative, there would be approximately 462 waterbodies plus connecting streams that would continue to contain self-sustaining nonnative trout populations, which is a long-term adverse effect on the natural quality of wilderness. The 87 waterbodies proposed for fish removal and restored to natural conditions under this alternative represent 16% of the parks’ 549 waterbodies known to contain nonnative fish that are candidates for eradication.

Aquatic ecosystem restoration would occur over the next 25-35 years in 41 basins, including the eradication of nonnative fish in 20 basins (82 lakes and ponds, 5 fish-containing marshes, approximately 41 miles (66 km) of streams, plus connected fish-containing habitat as necessary). Restoration of natural conditions would occur over a larger area because nonnative fish would be eliminated in some of these areas by the use of piscicides, which is more effective than the other methods, and can be used in larger areas, allowing for the recovery of invertebrate, amphibian, reptile, bird, and bat communities and native species populations to a more natural condition. MYLFs in restoration areas would return to more natural conditions to the extent that chytrid fungus and other stressors (e.g., climate change, air pollution) can be mitigated.

Effects on MYLF and Yosemite Toads (species likely to be listed under the ESA in 2014)
Most, but not all, of the MYLFs in the treatment areas are expected to be captured and moved out of treatment areas (see Mitigation Measures). Any tadpoles are not captured and moved would be affected by piscicide treatments, because tadpoles breathe through gills (rotenone targets gill-breathing organisms) and tadpoles cannot leave the water. CFT Legumine™ application concentrations of 1 ppm (=50 ppb rotenone) in streams and 4 ppm (=200 ppb rotenone) in lakes exceed the 24 hr LC50 concentration of 5 ppb rotenone for northern leopard frog tadpoles (Rana pipiens; Hamilton 1941), and 30 ppb rotenone for southern leopard frog tadpoles (Rana sphenocephala; Chandler and Marking 1982). Since these species are in the same genus as MYLFs (Rana muscosa and Rana sierrae), MYLF tadpoles are expected to have similar rotenone LC50 concentrations as leopard frog tadpoles.

However, the specific response of tadpoles to rotenone depends on development stage (Hamilton 1941). Younger larvae that are dependent on gill respiration are far more sensitive than older larvae that are near metamorphosis and breathing air. Therefore, the majority of younger MYLF tadpoles exposed to piscicide treatments would be expected to experience mortality, while a small percentage may be affected but would survive. In contrast, it is expected that some older tadpoles would be killed, while some would be affected but would survive.

Adult MYLFs that are not captured and moved would not be expected to be harmed when rotenone is applied at normal piscicidal concentrations (Farringer 1972), because frogs primarily breathe through skin and they can leave the water. Adult amphibian skin may be more of a barrier to rotenone than gills due to skin having a smaller relative surface area and a greater relative distance for rotenone to diffuse across (Fontenot et al. 1994). In addition, CFT Legumine™ application concentrations of 1 ppm (=50 ppb rotenone) in streams and 4 ppm (=200 ppb rotenone) in lakes do not exceed the 24 hr LC50 concentration of 240 to 1,580 ppb rotenone for northern leopard frog adults (Farringer 1972). As with tadpoles, MYLF adults are expected to have similar rotenone LC50 concentrations as leopard frog adults. Therefore, piscicide treatment would not be expected to kill adults, although some adults may be affected (e.g. expending energy on flight responses) but would survive.

Amphibian eggs are thought to be less sensitive to rotenone because their rate of chemical uptake from water is much lower than tadpoles or fish (Ling 2003). In addition, piscicide treatments are expected to be conducted in August or September, after all MYLF eggs would have hatched. Piscicide treatments are therefore expected to have no effect on MYLF eggs.

Due to the distance between treatment sites and extant MYLF populations, MYLFs present in untreated waterbodies adjacent to piscicide treated waterbodies are expected to be able to migrate into the treated areas with no adverse effects shortly (several days) after the treatment is concluded (Pope and Matthews 2001). If any MYLFs arrived within 1 to 2 days after treatment, they likely would all be frogs (not tadpoles), which do not have gills and thus would be expected to not be affected by habitat conditions.

Two stream sections in Upper Evolution are proposed for fish removal using piscicides, and thus there is potential for Yosemite toads to be affected by a piscicide treatment in this treatment area. However, the treatment would be conducted in August or September, after all Yosemite toad adults would have finished breeding and likely moved from aquatic to nearby terrestrial habitat, which is their typical post-breeding behavior (Kagarise Sherman 1980). In addition, many and potentially all tadpoles would have metamorphosed into juvenile toads, which also often move from breeding ponds to adjacent terrestrial habitat. Furthermore, if any individuals are observed in treatment habitat, the “capture-and-move” mitigation as described under the “Mitigation Measures” section of this document would be implemented, which would further reduce the number Yosemite toads that would be affected by the treatment.

Effects on the threatened Little Kern golden trout
This alternative proposes to eradicate fish from Crytes Basin using a combination of physical methods (i.e. gill netting and electrofishing in one lake and one lake/pond complex), piscicides (rotenone in adjacent streams), and blasting (if necessary) in one location. The fish population in the lake/pond complex, considered to be a population of federally threatened Little Kern golden trout, would be eradicated and thus adversely affected. However, this population is nonnative, the basin is not in designated critical habitat and is not part of the recovery plan, and recent genetic analysis shows this population is introgressed (not genetically pure).

Although this population is not genetically-pure, it still may have value in that it retains some amount of Little Kern golden trout alleles. If these fish are determined useful as brood stock for management and restoration of Little Kern golden trout within the recovery plan area, SEKI would work with CDFW to live-capture and move as many fish as possible to an appropriate location outside of the project area.

Effects on the endangered Sierra Nevada Bighorn Sheep
This alternative proposes to eradicate fish from both Sixty Lake and Laurel Basins using piscicides (rotenone in lakes/ponds and adjacent streams). In these basins, bighorn sheep are not expected to be present near treatment waterbodies. However, if any sheep are present, it is expected that there would be little effect as sheep have been shown to be habituated to human activity in many locations (including in the Rocky Mountains and in desert habitats (FWS 2007B)). Sheep would be expected to exhibit no more than a slight flight response due to the presence of treatment crews. If individuals are present near crew hiking routes, some individuals may exhibit a flight response, but this would be no different than what would occur when visitors hike through the area.

Although bighorn sheep are not expected to be present near treated waterbodies during the treatment period, there is a slight potential for individuals to come near treatment waterbodies shortly after the treatment period. Although the piscicide would be neutralized with potassium permanganate, a small amount of residue may remain in the surface water (EPA 2007A). However, since terrestrial animals are largely insensitive to rotenone, there is a substantial safety margin between the maximum concentrations needed for treatment and those necessary to harm terrestrial organisms (Ling 2003). Nevertheless, there are rotenone toxicity data for mammals, but they only analyze effects from consuming fish killed by rotenone. Since bighorn sheep are herbivores and thus do not consume fish or other animals, rotenone toxicity data are not available for bighorn sheep. As a proxy, data for acute dietary exposure to rotenone for humans was utilized, with the exposure acquired through drinking water containing rotenone residues.

The EPA (2007a) determined the estimated drinking water concentration (EDWC) to be 200 ppb, which is the solubility limit of rotenone. Estimated exposure from drinking water considered surface water only because rotenone is not expected to reach groundwater, and the estimate is conservative because it assumes water is consumed immediately after treatment with no breakdown or neutralization prior to consumption. EPA estimated acute dietary exposure to rotenone for humans at 0.0111 mg/kg/day, which is 26% less than the acute population adjusted dose (aPAD) of 0.015 mg/kg/day. Since the EPA is concerned when risk estimates exceed 100% of the aPAD, the EPA concluded that acute dietary risk from rotenone to humans is below the level of concern (see Appendix H for more information). Bighorn sheep are comparable in size to adult humans; adult females (ewes) weigh between 100 and 155 pounds and adult males (rams) can weigh between 120-200 pounds. Since risk to humans from drinking water with rotenone residue is below the EPA level of concern, risk to bighorn sheep from drinking water with rotenone residue is also expected to be below the level of concern, immeasurable, and highly unlikely to occur.

Effects on other vertebrates due to piscicide use would be as follows.

Amphibians (Pacific treefrog)
There is potential for Pacific treefrogs to be affected by piscicide treatments. However, treatments would be conducted in August or September when all Pacific treefrog adults would have finished breeding and likely moved from aquatic to nearby terrestrial habitat, which is their typical post-breeding behavior (Liang 2010). In addition, many and potentially all tadpoles would have metamorphosed into froglets, which also often move from breeding ponds to adjacent terrestrial habitat. Furthermore, if any individuals are observed in treatment habitat, we would implement the same “capture-and-move” mitigation as described in Special-Status Species, which would minimize the number of Pacific treefrogs that would be affected by the treatment. These mitigations include capturing as many individuals as possible and moving them to adjacent untreated waterbodies before piscicide treatments are conducted. If Pacific treefrogs are present in the treatment areas, most, but not all, of them are expected to be captured and moved out of treatment areas.

If any Pacific treefrog tadpoles are not able to be captured and moved, they would be expected to be affected by piscicide treatments. CFT Legumine™ application concentrations of 1 ppm (=50 ppb rotenone) in streams and 4 ppm (=200 ppb rotenone) in lakes exceed the 24 hr LC50 concentration of 5 ppb rotenone for northern leopard frog tadpoles (Rana pipiens; Hamilton 1941), and 30 ppb rotenone for southern leopard frog tadpoles (Rana sphenocephala; Chandler and Marking 1982). Although these species are not in the same genus as the Pacific treefrog, it is probable that Pacific treefrog tadpoles would have similar rotenone LC50 concentrations as leopard frog tadpoles.

The specific response of tadpoles to rotenone depends on development stage (Hamilton 1941). Younger tadpoles that are dependent on gill respiration are far more sensitive than older tadpoles that are near metamorphosis and breathing air. Therefore, younger Pacific treefrog tadpoles exposed to piscicide treatments would be expected to experience mortality, while a small percentage may be affected but would survive. In contrast, some older tadpoles may experience mortality, while some may be affected but would survive.

If any Pacific treefrog adults are not able to be captured and moved, they would not be expected to be harmed when rotenone is applied at normal piscicidal concentrations (Farringer 1972), because adult frogs do not have gills (they primarily breathe through skin). CFT Legumine™ application concentrations of 1 ppm (=50 ppb rotenone) in streams and 4 ppm (=200 ppb rotenone) in lakes do not exceed the 24 hr LC50 concentration of 240-1580 ppb rotenone for northern leopard frog adults (Farringer 1972). Similar to tadpoles, it is probable that Pacific treefrog adults have similar rotenone LC50 concentrations as leopard frog adults. Therefore, Pacific treefrog adults exposed to piscicide treatments would not be expected to experience mortality, and some may be affected but would survive.

Amphibian eggs are thought to be less sensitive to rotenone because their rate of chemical uptake from water is much lower than tadpoles or fish (Ling 2003). In addition, piscicide treatments would be conducted in August or September, after all Pacific treefrog eggs would have hatched. Piscicide treatments are therefore expected to have little effect on Pacific treefrog eggs.

Pacific treefrogs present in untreated waterbodies adjacent to piscicide treatment waterbodies are expected to be able to move into the treatment areas with no adverse effects shortly (several days) after the treatment is concluded (Billman et al. 2012). The eradication of nonnative trout from the piscicide treatment waterbodies would provide a large increase in habitat for Pacific treefrogs occupying these basins, with expected corresponding benefits over time of enhanced survival, growth and reproduction. Overall, piscicide treatments are expected to have minor short-term adverse effects, and long-term beneficial effects on Pacific treefrogs.

Reptiles (Mountain Garter Snake, Sierra Garter Snake)
Although few studies have examined rotenone toxicity to reptiles, Fontenot et al. (1994) conclude the following: freshwater aquatic snakes do not breathe using gills, and it is very unlikely that absorption of rotenone will occur through the thick skin of snakes. However, Haque (1971, as cited in Fontenot et al. 1994) reported the death of one aquatic snake 48 hours after a pond rotenone treatment, while a second snake in the same pond at the same time was swimming in a healthy manner. Although additional studies would clarify the toxicity of rotenone to reptiles, garter snakes are expected to rarely be present in piscicide treatment areas, because they are rarely present in fish-containing lakes in the parks (NPS 2012A). Piscicide treatments are therefore expected to have short-term negligible to minor adverse effects and long-term beneficial effects on reptiles.

Birds (Gray-crowned Rosy Finch, Clark's Nutcracker, Brewer's Blackbird, American Robin, Spotted Sandpiper, Eared Grebe)
The EPA (2007A) concluded that: 1) birds that forage on terrestrial items have little risk of exposure to rotenone residues because rotenone is applied directly to water, and 2) although some birds that forage on fish may opportunistically feed on dead or dying fish in treatment areas, it is unlikely to result in a lethal dose. The EPA based this conclusion on a study (Jarvinen and Ankley 1998) that found 0.22 micrograms per gram (µg/g) of rotenone residue in yellow perch (Perca flavescens) killed by rotenone. Since yellow perch are similar in size to trout, it is probable that trout treated in the parks would also contain similar residues of rotenone.

The average weight of all trout captured in the parks in a survey of high elevation lakes from 1997 to 2002 (Knapp 2003) was 76 g, which, if treated with rotenone would contain approximately 17 µg of rotenone after treatment (76 g × 0.22 µg/g). A juvenile American robin (average weight approximately 55 g at fledging; Howell 1942) would therefore have to consume about 647 trout to reach its reported median lethal dose of 200 mg/kg rotenone (200 mg/kg × 0.055 kg robin = 11 mg = 11,000 µg ÷ 17 µg = 647) (Cutkomp 1943; see Appendix G). Although many of the trout in a treatment area will decompose in deep water and thus not be available for consumption by birds, treated fish that do not sink may be scattered in upland areas and thus have the potential for partial consumption by birds.

Bird species known to occur in the project area that may consume treated fish include Clark's nutcracker, Brewer's blackbird, American robin, and eared grebe. All of these species primarily consume insects, other invertebrates, and seeds, and only opportunistically feed on vertebrates. Nevertheless, if any birds did consume treated fish, their exposure to rotenone is expected to be low due to the small amount of rotenone residue present in treated fish, and the small amount of fish tissue that birds would eat because of their relatively low daily intake of calories. Gray-crowned rosy finch and spotted sandpiper are not expected to consume treated fish because they are only known to consume insects and other invertebrates.

Since all of the bird species consume invertebrates, they are expected to be indirectly affected by the short-term loss of aquatic invertebrates and zooplankton in lakes and streams treated with piscicides. However, the treatment lakes already have reduced invertebrate and zooplankton assemblages due to the presence of nonnative trout (Knapp et. 2001, Knapp 2005), so the effect is expected to be negligible. In addition, all of the treatment areas have nearby lakes and streams that will not be treated, and thus invertebrate food will be available at natural levels in adjacent habitat. Since birds fly (are highly mobile), they are expected to easily be able to feed more at untreated lakes and streams relative to treatment areas. This effect is expected to largely end in the summer following a treatment (no more than one year), as studies show that invertebrate assemblage abundances typically recover rapidly and approach pre-treatment levels between 9 months and 1 year after piscicide treatment (Binns 1967, Cook and Moore 1969, Hamilton et al. 2009). Further increases of invertebrates and zooplankton are then expected to return to more natural levels over the course of several years following fish removal (Knapp et al. 2001, Knapp 2005, Hamilton et al. 2009), which would have long-term beneficial effect on the bird species.

Mammals (Northern Water Shrew, Coyote, Eight Species of Bats)
Northern water shrews present in a treatment area are not expected to be affected by piscicide treatments because they do not use gills for respiration. In addition, EPA (2007A) concluded that wild mammals are not likely to have significant exposure to rotenone residues because: 1) most dead fish tend to sink where they are not available for terrestrial consumption, and 2) in the event that mammals forage on accessible dead or dying fish, it is unlikely to result in observable acute toxicity.

Although coyotes are known to occur in the project area, restoration crews in the parks from 2001 to 2011 have only rarely observed them. In addition, coyotes are not expected to be present in treatment areas during daylight hours while crews are active, but it is possible they could enter treatment areas during night hours. Coyotes are suspected to have fed on fish caught in gill nets in one shallow treatment lake (NPS unpublished data), where two nets were dragged to shore and fish were gnawed in an area where coyotes were heard. Although coyotes appear to opportunistically feed on fish, coyotes present in a treatment area are not likely to have significant exposure to rotenone residues because: 1) most dead fish tend to sink where they are not available for terrestrial consumption, and 2) in the event that mammals forage on accessible dead or dying fish, it is unlikely to result in observable acute toxicity.

Effects of piscicide treatments on bats are expected to be similar to the bird species, as bats also feed on invertebrates emerging from lakes and streams. The reduction of invertebrates for roughly one year from habitat treated with piscicides would be mitigated by the natural amount of invertebrates emerging from nearby untreated habitat, resulting in short-term negligible to minor adverse effects on the bat species. Conversely, the recovery and substantial increase of invertebrates expected following fish removal in treated habitat is likely to result in long-term beneficial effects on the bat species.

Effects on Invertebrates
Pre- and post-treatment monitoring involving the collection of invertebrates would result in mortality of individuals on a small scale. However this activity would affect individual and the populations would remain intact.

Effects on the invertebrates due to piscicide use (rotenone) are described in the following analysis, which draws heavily, including excerpted sections, from analyses conducted for these similar recent documents:

- Piscicides and Invertebrates: After 70 Years, Does Anyone Really Know? (Vinson et al. 2010)
- Paiute Cutthroat Restoration Project Draft EIS/EIR (FWS-CDFW 2010)
- Proposed Use of Rotenone to Eradicate Northern Pike in Lake Davis, California Draft EIS/EIR (CDFW 2007)
- Reregistration Eligibility Decision for Rotenone (EPA 2007A)

Based on these analyses and many other studies and projects, many invertebrates present in rotenone treatment areas would be expected to be affected by piscicide use. Effects may include mortality of individuals and variable effects on the composition of invertebrate assemblages, both of which would be unavoidable consequences of rotenone treatment to eradicate nonnative trout.

Rotenone is toxic to many gill-breathing organisms when applied in water because it is readily transmitted across gill surfaces and quickly disrupts cellular aerobic respiration (Finlayson et al. 2000). It therefore prevents fish and certain aquatic invertebrates and zooplankton from extracting oxygen from water, which is essential for respiration and energy production (Singer and Ramsay 1994). Since fish quickly absorb rotenone across gill surfaces, they are extremely sensitive to rotenone treatments. Although sensitivity varies by species, trout are among the most sensitive fishes to rotenone (Marking and Bills 1976), dying within hours at application concentrations below 1 part per million (ppm) in streams (Ling 2003). All project waterbodies proposed for fish eradication only contain brook trout and/or forms of rainbow trout. Although many aquatic invertebrates and zooplankton also use gills and thus are affected by rotenone treatments, they are generally more tolerant of rotenone than trout, as described in the following sections.

Rotenone effects on various aquatic organisms have been reported from controlled toxicity tests that typically measure the LC50 value (median water concentration of active ingredient that kills 50 percent of test animals) over a period of time (typically 24 hrs and/or 96 hrs). A review of many aquatic invertebrate taxa shows a range of sensitivity to rotenone (Table 20; from a variety of sources as summarized by Ling 2003). The table shows a mollusc [96hr LC50 = 7.5 mg/L (ppm) = 7,500 ppb], a snail (24hr LC50 = 6.35 mg/L = 6,350 ppb)], and a freshwater prawn (24hr LC50 = 5.15 mg/L = 5,150 ppb) as the most rotenone-resistant taxa included in this review, while Branchiura (lice; 24hr LC50 = ~0.025 mg/L = 25 ppb), Conchostracan (clam shrimps; 24hr LC50 = ~0.05 mg/L = 50 ppb), and Hydrachnidae (water mites; 96hr LC50 = ~0.05 mg/L = 50 ppb) were the most rotenone-sensitive taxa reported. However, the most sensitive invertebrate taxa are still 7 to 14 times more resistant to rotenone than the most resistant fish taxa in SEKI proposed eradication sites (rainbow trout; 24hr LC50 = 3.5 ppb; Marking and Bills 1976).

Rotenone toxicity reported in several aquatic invertebrate taxa.

Species Guild	Species	Test Endpoint	LC (mg/L)	Reference
Flatworm	*Catenula* sp.	LC_{50} 24h	5.100	Chandler 1982
	Planaria sp.	LC_{50} 24h	<0.500	Hamilton 1941
Annelid worms	Leech	LC_{50} 24h	<0.1	Hamilton 1941
Copepod	*Cyclops* sp.	LC_{100} 72h	<0.100	Meadows 1973
Branchiura	*Argulus* sp.	LC_{50} 24h	~0.025	Hamilton 1941
Cladoceran	*Daphnia pulex*	LC_{50} 24h	0.027	Chandler 1982
	Daphnia pulex	LC_{50} 24h	<0.025	Hamilton 1941
	Diaptomus siciloides	LC_{50} 24h	<0.025	Hamilton 1941
Ostracod	*Cypridopsis* sp.	LC_{50} 24h	0.490	Chandler 1982
Conchostracan	*Estheria* sp.	LC_{50} 24h	~0.050	Hamilton 1941
Freshwater prawn	*Palaemonetes kadiakensis*	LC_{50} 24h	5.150	Chandler 1982
Crayfish	*Cambarus immunis*	LC_{50} 24h	>0.500	Hamilton 1941
Dragonfly naiad	*Macromia* sp.	LC_{50} 24h	4.700	Chandler 1982
Stonefly naiad	*Pteronarcys californica*	LC_{50} 24h	2.900	Sanders and Cope 1968
Backswimmer	*Notonecta* sp.	LC_{50} 24h	3.420	Chandler 1982
	Notonecta sp.	LC_{50} 24h	~0.100	Hamilton 1941
Caddis fly larvae	*Hydropsyche* sp.	LC_{50} 24h	0.605	Chandler 1982
Whirligig beetle	*Gyrinus* sp.	LC_{50} 24h	3.550	Chandler 1982
Water mite	Hydrachnidae	LC_{50} 96h	~0.050	Hamilton 1941
Snail	*Physa pomilia*	LC_{50} 24h	6.350	Chandler 1982
	Oxytrema catenaria	LC_{50} 96h	1.750	Chandler 1982
	Lymnaea stagnalis	LC_{50} 96h	>1.000	Hamilton 1941
Bivalve Mollusc	*Dreissena polymorpha*	LC_{50} 24h	0.219	Waller et al. 1993
	Obliquaria reflexa	LC_{50} 24h	>1.000	Waller et al. 1993
	Elliptio buckleyi	LC_{50} 96h	2.950	Chandler 1982
	Elliptio complanata	LC_{50} 96h	2.000	Chandler 1982
	Corbicula manilensis	LC_{50} 96h	7.500	Chandler 1982
LC = Lethal Concentration				

Another review also shows that susceptibility of individual invertebrates to rotenone varies widely (Vinson and Vinson 2007). They report that 96 hr LC50 rotenone toxicity to benthic macroinvertebrates ranges from 2 to 100,000 ppb, and also varies within and among invertebrate taxonomic groups. Depending on exposure time, mortality can be near 100% at concentrations greater than 50 to 75 ppb rotenone for stream invertebrates and 150 ppb rotenone for lake adult aquatic invertebrate groups such as Heteroptera (true bugs) and Coleoptera (beetles). However, many of the studies reviewed reported results of 96 hr exposure, which is 16 to 24 times longer than the 4 to 6 hr durations planned for each rotenone treatment under this alternative.

Rotenone sensitivity by individual species and life stages appears to depend on body size, morphology and habitats used (Vinson et al. 2010), as well as differing oxygen uptake processes (Engstrom-Heg et al. 1978). Smaller invertebrates appear more sensitive than larger invertebrates, and species that use gills to extract aqueous oxygen are more sensitive than those that obtain oxygen through other means (Vinson et al. 2010). Larvae from the EPT taxa group [Ephemeroptera (mayflies), Plecoptera (stoneflies) and some Trichoptera (caddisflies)] all use gills. They are more sensitive to environmental stressors than other aquatic invertebrate groups, and some EPA taxa were not detected 5 years after a few rotenone treatments such as Mangum and Madrigal (1999), although this project used very high concentrations and durations. Rotenone sensitivity can also vary within the same group. Whelan (2002) reported that while caddisflies had the highest number of species affected by rotenone, many caddisflies were tolerant.

Since the anatomies of many aquatic invertebrate taxa contain gill-like structures, they should theoretically be as susceptible to rotenone as fish or amphibian larvae (Bradbury 1986). In laboratory tests, however, Chandler and Marking (1982) concluded that aquatic invertebrates are generally much more tolerant of rotenone than most fishes and amphibian larval stages. A snail (*Helisoma sp.*) and the Asiatic clam (*Corbicula manilensis*) were the most resistant taxa studied, with 96 hr LC50 concentrations that were 50 times greater than the most resistant fish (black bullhead) studied by Marking and Bills (1976). Another study (Sanders and Cope 1968) measured rotenone effect on subadult stages of a stonefly (*Pteronarcys californica*). They showed 24 hr and 96 hr LC50 concentrations of 2,900 ppb and 380 ppb, respectively, which are an order of magnitude greater than those reported for black bullhead (24 hr LC50 = 33.3 ppb). They also showed that larger, older subadults were less susceptible to given concentrations of rotenone than smaller, younger subadults of the same taxa.

Although results indicate that many aquatic invertebrates are less sensitive to rotenone than fish, acute invertebrate mortality is still expected from a typical rotenone application. Rotenone treatments thus often result in short term (9 month to 1 year) decreases in invertebrate abundance (20–85%; Engstrom-Heg et al. 1978, Darby et al. 2004) and diversity (Binns 1967, Cook and Moore 1969, Engstrom-Heg et al. 1978, Mangum and Madrigal 1999, Whelan 2002).

However, rotenone treatment may not be toxic to all aquatic invertebrates, as CDFW found in tests of benthic macroinvertebrate exposure to CFT Legumine™ and Nusyn-Noxfish (another rotenone formulation). Aquatic invertebrates considered representative of a proposed stream treatment area were collected and exposed to a range of rotenone concentrations that encompassed the planned treatment concentrations of 25 to 50 ppb rotenone. Results showed 4 hr LC50 values ranged from 41 to 274 ppb rotenone and 8 hr LC50 values ranged from 13 to 174 ppb rotenone for various species of caddisflies, mayflies and stoneflies (CDFW unpublished data). Results show that treatment concentrations of 25 to 50 ppb rotenone would have differential effects on these species, including being below the “no observed effect level” (NOEL) for some species.

A comprehensive review of published studies on the effects of rotenone treatment on invertebrate assemblages (Vinson et al. 2010) found that reported recovery varied widely, with several studies reporting few effects and several studies reporting substantial effects. They attributed these differences as resulting from three factors including: 1) rotenone concentration, duration and treatment area, 2) study objectives and sampling intensity, and 3) variation in toxicity among taxa and taxonomic groups. Higher rotenone concentration levels almost always led to greater effects on invertebrates. Although a mean concentration of 25 to 50 ppb rotenone for less than 8 hours has been suggested to achieve full trout mortality while minimizing invertebrate mortality (Finlayson et al. 2010), most fish removal projects used higher dosages, including one with a maximum concentration of 470 ppb rotenone (Binns 1967).

Differences among invertebrate morphologies and habitats occupied also appear to have considerable influence on the effects of rotenone on invertebrates (Vinson et al. 2010). For example, planktonic invertebrates that occupy open water appear more sensitive than benthic invertebrates that occupy substrate habitat. In addition, smaller invertebrates appear more sensitive than larger invertebrates; and aquatic invertebrates that use gills appear more sensitive than those that acquire oxygen through other means. This last point suggests rotenone may have greater effects in high elevation streams where cold water and high oxygen levels favor usage by small gilled invertebrates often dominated by EPT taxa. However, these taxa are much more benthic than planktonic, which appears to mitigate effects of rotenone. Although studies in mountain streams have generally showed EPT taxa to be more susceptible to rotenone than other taxonomic groups (Binns 1967, Mangum and Madrigal 1999, Whelan 2002, Hamilton et al. 2009), several of these projects (Binns 1967, Mangum and Madrigal 1999, Hamilton et al. 2009) used substantially higher rotenone dosages than necessary. Using recommended dosages would therefore limit effects of rotenone.

Many studies have assessed aquatic invertebrate recovery from rotenone treatment by measuring how taxa return toward pre-treatment levels. Some studies measured abundance and biomass (Binns 1967, Cook and Moore 1969, Engstrom-Heg et al. 1978), while others measured taxa richness or other diversity indices such as EPT Index (Whelan 2002, Darby et al. 2004). One study (Mangum and Madrigal 1999) primarily measured whether individual taxa present before treatment returned after treatment, however, most studies used a combination of metrics.

Invertebrate recovery to pre-treatment levels following rotenone treatment has occurred rapidly (<1 year) in some but not all studies (Ling 2003). Recovery time for aquatic invertebrate assemblages have ranged from several months to several years depending on the metrics selected and study length. Assemblage abundances typically return to pre-treatment levels within one year (Binns 1967, Cook and Moore 1969, Beal and Anderson 1993, Mangum and Madrigal 1999, Melaas et al. 2001, Whelan 2002), while diversity and community composition took more than 2 years in some studies (Binns 1967, Whelan 2002). A few individual taxa had not recovered after 5 years in two studies (Mangum and Madrigal 1999, Hamilton et al. 2009), however, both of these studies treated at higher rotenone concentrations than currently recommended. Vinson et al. (2010) attributed these differing results to variation in colonization rates among taxa and amounts of pre- and post-treatment sampling.

Aquatic invertebrate communities tend to recover relatively quickly following rotenone treatment (Ling 2003), with studies showing rapid biomass increases following initial depletions from rotenone treatment (Cook and Moore 1969, Neves 1975). Similarly, Dudgeon (1990) found that stream rotenone treatments caused immediate invertebrate drift, particularly of mayflies, but did not cause significant mortality or a significant reduction in abundance of benthic invertebrates. (Invertebrate drift is when invertebrate larvae in streams are dislodged from substrates and carried downstream by flows.) Nevertheless, varied results of rotenone effect on aquatic invertebrate communities have also been reported, with some showing negligible effects (Demong 2001, Melaas et al. 2001) and others showing longer-term negative effects (Binns 1967, Mangum and Madrigal 1999).

Although aquatic invertebrates are affected by rotenone, certain natural characteristics may mitigate the effects. For example, taxa in the EPT group are typically highly mobile and have short life cycles, and therefore should rapidly repopulate treated areas through dispersal and reproduction (Engstrom-Heg et al. 1978). Further, rotenone exposure to aquatic invertebrates may be reduced by behaviors such as burrowing, associating with vegetation or the ability to trap air bubbles with appendages (CDFW 2007). Moreover, rotenone toxicity to aquatic invertebrates may be moderated by physical and chemical attributes of the treated ecosystem (Melaas et al. 2001).

Only a few studies have conducted 2 or more years of post-treatment sampling to assess aquatic invertebrate assemblage recovery following rotenone treatments (Binns 1967, Mangum and Madrigal 1999, Whelan 2002, Darby et al. 2004, Hamilton et al. 2009).

Binns (1967) reported that rotenone treatment of 435 miles of the Green River, Wyoming had a target concentration of 250 ppb rotenone, but the concentration reached 470 ppb rotenone in some areas. These concentrations are 5 to 9 times higher than the current limit of 50 ppb rotenone for trout removal in streams (EPA 2007A). Two years after treatment the composition of dominant invertebrate groups was different from pre-treatment assemblages and two genera of Ephemeroptera had not reappeared. However, the abundances of Ephemeroptera, Trichoptera and Chironomidae increased during these 2 years after treatment, with larger increases in upstream treatment areas, potentially due to colonization from upstream untreated areas.

Mangum and Madrigal (1999) reported that the entire Strawberry River, Utah received two rotenone treatments within a single year. The treatments were applied at 150 ppb rotenone for 48 hours, which is 3 times the current limit of 50 ppb rotenone and at least 6 times longer than currently recommended rotenone durations of less than 8 hours (Finlayson et al. 2010). Total invertebrate abundance recovered within 1 to 36 months among their sample sites, however, community composition had not fully recovered by the end of the study. For example, soon after the treatments they detected 33% of the taxa detected before treatment; 1 year after the treatments they detected 46% of the taxa detected before treatment; and 5 years after the treatments they detected 79% of the pre-treatment taxa. The strong rotenone treatments may have been responsible for the lack of recovery of some taxa after 5 years. Most of the taxa were in the EPT group, although some taxa in each of these groups were present and therefore more resistant and/or resilient to rotenone. In addition, other taxa not present before the treatments were detected after the treatment, showing that a shift in taxonomic composition may have occurred, with new taxa possibly filling niches vacated by those that failed to recover. Potential effects on invertebrate communities from proposed treatments under this alternative, with 25 to 50 ppb rotenone concentrations for less than 8 hours, would be expected to be moderately to substantially lower than those measured in Strawberry River, Utah.

Whelan (2002) reported that Manning Creek, Utah received rotenone treatment in 2 successive years. The treatments were applied at 150 ppb rotenone for 12 to 18 hours, which is three times the current limit of 50 ppb rotenone and at least 1.5 to 2.25 times longer than currently recommended rotenone durations of less than 8 hours. Invertebrate samples were collected zero, 5 and 7 years before the treatments, and 1 and 3 years after the treatments. About 50% of taxa were detected both before and after the treatments, 21% were detected only before the treatments, and 30% were detected only after the treatments. The taxa found only during the after-treatment surveys were considered rare taxa, and sampling errors in detecting rare taxa contributed to their non-detection in the before-treatment surveys. The most affected group was Trichoptera, in which about 10% of taxa detected before the treatments were not detected 3 years after the treatments.

Darby et al. (2004) and Hamilton et al. (2009) reported that Strawberry Creek, Great Basin National Park (GRBA), Nevada received rotenone treatment, which was applied at 250 ppb rotenone for 1 hour and then 100 ppb rotenone for 7 hours, which is 2 to 5 times the current limit of 50 ppb rotenone. Following treatment, the following results were reported.

Total invertebrate abundance:

- declined to 15% of pre-treatment levels after 1 month, then
- recovered to 66% of pre-treatment levels after 2 years;
- recovery after 3 years was not reported

EPT abundance:

- declined to 1% of pre-treatment levels after 1 month, then
- recovered to 44% of pre-treatment levels after 2 years;
- recovery after 3 years was not reported.

Taxa richness:

- declined to 32% of pre-treatment levels after 1 month, then
- recovered to 90% of pre-treatment levels after 2 years, and
- recovered to 96% of pre-treatment levels after 3 years (2 EPT taxa had not recovered).

EPT Taxa richness:

- declined to 14% of pre-treatment levels after 1 month, then
- recovered to 77% of pre-treatment levels after 2 years, and
- recovered to 92% of pre-treatment levels after 3 years (2 EPT taxa had not recovered).

Potential effects on invertebrate communities from proposed treatments under this alternative, with 25 to 50 ppb rotenone concentrations, would be expected to be lower than those measured in GRBA.

Trumbo et al. (2000b) reported that Silver Creek, California received repeated rotenone treatments that were applied at 50 ppb rotenone. Overall invertebrate abundances were not affected but large Plecopterans (stoneflies) were affected. Although study conclusions were limited by little pre-treatment data, there were reductions of 6.6% in the DAT Diversity Index and 8.4% in the Biodiversity Collections Index. Certain taxa were thus affected by rotenone applied at 50 ppb, and short-term shifts in diversity occurred but not to a substantial degree (<10% divergence from baseline levels).

These longer-term studies suggest that invertebrate recovery can occur within as little as 2 months or could take more than 5 years. However, each study assessed recovery differently, making it difficult to compare recovery times. Comparison is also challenged by treatment specifics (such as rotenone concentration); inadequate pre-treatment monitoring (sometimes 1 to 2 sampling events); the highly variable nature of invertebrate assemblages over time and space; lack of adequate control or reference sites; and factors that influence recolonization potential (Vinson et al. 2010).

Niemi et al. (1990) reviewed 150 studies of aquatic ecosystem recovery from disturbance (15 involving rotenone treatments). They reported that: 1) recovery times were slightly quicker for small streams (1st to 3rd order) versus larger rivers (4th to 5th order); and 2) total invertebrate assemblage abundances recovered to 85% of pre-disturbance densities in generally less than 18 months, while recovery of abundances of different invertebrate taxonomic groups and individual taxa varied widely. Recovery abundances were near 80% for Diptera (true flies) after one year, 70% for Ephemeroptera after one year, and about 60% for Trichoptera and Plecoptera after 2 years. Although Coleoptera was not included in enough studies to make a quantified estimate, they predicted that Coleoptera recovered more slowly than Trichoptera and Plecoptera. They concluded that recovery time was well influenced by taxa generation time and dispersal ability, and distance from colonization sources. They also concluded that downstream drift from untreated upstream stream sections was a critical factor influencing stream invertebrate recovery times, following disturbances that did not physically affect habitat (piscicide treatment rather than flood or fire). Since some of the taxa most sensitive to rotenone have winged life stages and short life cycles, they have the potential to rapidly recolonize treated areas through dispersal and egg laying (Engstrom-Heg et al. 1978). They summarized that rates of recovery of aquatic invertebrate assemblages were most influenced by: 1) impact persistence, 2) taxa generation time and dispersal ability, 3) month or season of disturbance, 4) presence of refugia, and 5) distance to recolonization sources.

Distinguishing between the effects of rotenone use, natural disturbance and population variability on aquatic invertebrate assemblages is imprecise. Indeed, the following bullets excerpted from FWS/CDFW (2010) describe how historical data are not easily compared and interpreting their results is complicated by several factors:

- Most studies have not collected adequate baseline (pre-treatment) data to allow comparison with post-treatment data.
- Most studies focused on gross measurements, such as richness or abundance, with little data on the effects of rotenone on individual taxa or post-treatment recovery.
- There were too few studies and to little comparability between studies to make broad statements about the long-term effects of rotenone.
- Sampling effort was often uneven, with more samples taken from treated sites, which affects the likelihood of sampling rare taxa and reduces comparability among sites.
- Some studies have not accounted for the natural variation that occurs in benthic macroinvertebrate communities or historic disturbances that may have affected that area.

Similarly, Vinson et al. (2010) concluded that invertebrate sampling conducted 1 year post-treatment appeared sufficient to detect piscicide effects on assemblage measures (such as total abundance and taxa richness) but not for individual taxa. For individual taxa not detected at 1 year post-treatment, the three longest-term studies conducted to date (Mangum and Madrigal 1999; Whelan 2002; Hamilton et al. 2009) reported that many (but not all) of these taxa were detected 2 to 3 years post-treatment This suggests that 1) sampling may have been inadequate in fully describing the local fauna and (2) aquatic invertebrate assemblages are very diverse and variable over time. Both of these attributes prevent reaching definitive conclusions as to whether natural variation, sampling variation, or piscicides are responsible for differences in taxa measured between pre- and post-treatment samples.

Studies show that it is difficult to detect changes in rare taxa and to attribute cause if changes are measured. For example, Whelan (2002) observed that most of the taxa absent after treatment in Manning Creek, Utah were rare in samples before treatment; some taxa detected several years before treatment were not detected immediately prior to treatment; and some taxa not collected in post-treatment samples were actually present via other observations. The author concluded that many of the missing taxa could recover from rotenone treatment because many of these taxa were found following rotenone treatment in Strawberry Creek, Nevada. In addition, Mangum and Madrigal (1999) primarily reported on the presence or absence of taxa following rotenone treatment in Strawberry River, Utah. For the missing taxa, they did not report their abundance in pre-treatment samples or the potential for these taxa to be absent due to other causes such as sampling variation. The comparability of this study is limited, however, because this project applied rotenone at substantially higher concentrations and longer duration than is currently allowed by EPA.

The review by Vinson et al. (2010) concluded that an extensive amount of sampling is necessary to obtain a comprehensive characterization of taxa present in invertebrate assemblages before and after a piscicide treatment. They report that because it is common for stream invertebrate assemblages to contain a large number of rare taxa, there have been no complete inventories of invertebrates of any stream (or body of fresh water). Nevertheless, they cite Strayer (2006) in reporting that stream assemblages can contain hundreds to thousands of species, including over 1,000 species from each of the Danube River, Austria and Breitenbach River, Germany. They report that most studies with periodic sampling over 1 to 2 years commonly detect 50 to 60 taxa in a 0.7 mile (1 km) stream reach.

However, the same location in Logan River, Utah was sampled monthly for 10 years (Vinson et al. 2010), following field (Vinson and Dinger 2008) and laboratory (Vinson and Hawkins 1996) protocols commonly used in piscicide assessment projects. Results showed little variation in the number of invertebrate genera detected each month, but the individual genera within each sample varied widely. A total of 84 genera were detected over the study period, but an average of only 27.5 genera (33% of total) was detected each month. A new genus was detected about every 2 months on average (Figure 14), and the genera accumulation rate was still increasing steadily after 10 years. Results are similar to two other studies (Needham and Usinger 1956, Resh 1979), suggesting that variation in stream invertebrate assemblages is so high that attempting to quantify the abundances of all but the most common taxa or the assemblage as a whole is likely beyond the scope of most assessment projects.

Vinson et al. (2010) concluded that treatment methods and sampling efforts among existing studies are too variable to allow for definitive conclusions on the effects of rotenone on aquatic invertebrates in general and stream invertebrates in particular. However, lower rotenone concentrations than have generally been used in the past may be able to achieve complete mortality of trout while minimizing effects on invertebrate assemblages (Finlayson et al. 2010). To further reduce rotenone effects and promote invertebrate recolonization, they recommend that upstream and tributary fishless sections be left untreated to serve as invertebrate refugia, and that rotenone should be neutralized to protect downstream colonization sources.

In light of the preceding review of available literature on the effects of rotenone and disturbance on aquatic invertebrates, the following conclusions summarize the potential effects on stream aquatic invertebrates that would be expected from rotenone use in SEKI under this alternative:

- Since rotenone effects may be greater in high elevation streams that are often dominated by small, gilled invertebrates (many EPT taxa) adapted to snowmelt systems, cold water and high oxygen level, short-term effects on aquatic invertebrates would be expected to be high. However, treatments would be applied at 25 to 50 ppb rotenone to minimize invertebrate mortality while still achieving complete mortality of trout. This would improve the ability of invertebrate assemblages to recover, relative to many projects that treated at higher concentrations.

- Since rotenone would be applied in late summer and invertebrate recovery would depend in part on downstream drift of larvae for recolonization, lower fall and winter drift rates and lack of winter reproduction would delay much recovery until the following spring. However, upstream and tributary fishless stream sections are expected to be present in each rotenone treatment basin and would not be treated. In addition, each treatment basin has adjacent fishless stream sections that would also not be treated. These habitats would provide nearby habitat sources for invertebrates to rapidly colonize treatment areas through drift or dispersal.

- Since the proposed rotenone treatment streams have predictable discharge patterns (snowmelt driven) and are presumed to have a relatively low frequency of natural disturbance (little to no fire; smaller and infrequent floods), invertebrate assemblages may be less resistant to rotenone treatment. However, the treatment basins are relatively small (compared to many projects that treated larger basins), which should limit distance to colonization sources and provide for quicker recovery times (versus treating larger basins).

- Common taxa would be expected to quickly recolonize treated areas; rarer taxa may not return for a number of years or indefinitely.

Effects of rotenone on aquatic invertebrates in lakes would be similar to effects on aquatic invertebrates in streams, as described in the preceding section. For effects of rotenone on zooplankton, There is a range of sensitivity to rotenone for two groups of zooplankton, including copepods (72 hr LC100 = <0.1 mg/L = 100 ppb) as the most rotenone-resistant taxa included in this review (Ling 2003), and cladocerans (24 hr LC50 = <0.025 to 0.027 mg/L = 25 to 27 ppb) as the most rotenone-sensitive taxa included. However, these zooplankton taxa are still 7 to 28 times more resistant than the most resistant fish taxa in SEKI proposed eradication sites (rainbow trout: 24 hr LC50 = 3.5 ppb).

Although these results indicate that zooplankton are much less sensitive to rotenone than fish, rotenone is still toxic to zooplankton (Kiser et al. 1963, Anderson 1970, Neves 1975, Beal and Anderson 1993, Melaas et al. 2001) and thus some mortality would be expected from a typical application in lakes or ponds. While many aquatic invertebrates may lessen rotenone exposure by burrowing into sediment, zooplankton typically occupy open-water habitat and thus are exposed to rotenone for the entire time it is active during a treatment (CDFW 2007). As a result, zooplankton taxa such as cladocerans are generally more sensitive than larger benthic invertebrates such as mollusks, oligochaete worms and chironomid midge larvae (Hamilton 1941, Morrison 1977). However, some zooplankton taxa do have resistant life stages and/or eggs that may facilitate recovery (Kiser et al. 1963).

In lakes, studies have primarily evaluated the effects of rotenone on zooplankton assemblages rather than benthic invertebrates, documenting short-term effects on zooplankton abundance and taxa richness. In a review of published studies on the effects of rotenone on lake invertebrates, Vinson et al. (2010) reported the following results. Almquist (1959) measured that most zooplankton experienced mortality at 25 to 30 ppb rotenone, and that the toxicity of rotenone in lakes varied in response to light, oxygen, alkalinity, temperature and turbidity. Kiser et al. (1963) observed complete mortality of a zooplankton assemblage within 2 days after applying 25 ppb rotenone. Similarly, Beal and Anderson (1993) found no surviving zooplankton 2 days after treatment with 15 ppb rotenone. Finally, Reinertsen et al. (1990) found a substantial reduction in zooplankton abundance after a 25 ppb rotenone treatment. Reductions are generally short-term, with populations of more-resistant taxa such as copepods recovering over periods of 1 to 8 months following treatment (Beal and Anderson 1993, Ling 2003). However, populations of more-sensitive taxa such as cladocerans sometimes needed 3 years to recover in mountain lakes (Anderson 1970).

Although lake studies have reported greater rotenone effects on zooplankton than on benthic invertebrates, studies nevertheless do show short-term effects on benthic invertebrates (Vinson et al. 2010). However, these studies typically showed small differences in total abundance or biomass between pre- and post-treatment samples (Cushing and Olive 1957, Houf and Campbell 1977, Melaas et al. 2001). The greatest effects appear to have been on Chironomidae (midges), which can be the most dominant taxa in invertebrate assemblages.

As introduced above, studies of rotenone effects on zooplankton in lakes most often reported recovery in terms of organism abundance (Vinson et al. 2010). Recovery of zooplankton to pre-treatment abundances ranged from 1 month to 3 years, with rotifer and copepod assemblages appearing to recover more quickly than cladoceran assemblages (Brown and Ball 1943, Anderson 1970, Beal and Anderson 1993).

Several studies have shown rapid and strong recovery of zooplankton assemblages in lakes following rotenone treatment. In Lake Davis, California, overall zooplankton abundance increased to roughly 300% of the pre-rotenone-treatment abundance, and all pre-treatment taxa were present, within 1 year after treatment (CDFW/USFS 2007). In another study, all 42 zooplankton taxa that were extirpated immediately following rotenone treatment returned within 5 months (Kiser et al. 1963). Finally, Melaas et al. (2001) reported complete recovery of prairie wetland zooplankton assemblages within 1 year of treatment.

Studies that assessed recovery of benthic invertebrate assemblages in lakes generally showed no long-term decreases in abundance or taxa richness (Houf and Campbell 1977); no difference in taxa richness within 6 months (Blakely et al. 2005); and no differences between pre- and post-treatment samples within 1 year of treatment (Melaas et al. 2001).

Therefore, while there would be an adverse effect on the natural quality of wilderness from the use of piscicides because of the impacts on native vertebrate and invertebrate population, these effects would be temporary; in the long-term there would be positive beneficial effects on the natural quality of wilderness character by restoring the natural components of the native high elevation aquatic ecosystems.

Undeveloped: Under this alternative, the undeveloped quality of wilderness would be affected by the presence of the equipment that would be used for the project work, including gill nets, small electric pumps used for piscicide applications, and barrier nets installed across streams and the use of helicopters.

The effects on the undeveloped quality of wilderness character from the installation of gill nets and fish traps would be short-term during project activities, and long-term when gill nets are deployed over the winter months. There would be up to six crew camps in wilderness per year, generally occupying each site periodically through the summer season for approximately 6 years per lake or pond treatment site, and up to 10 years at treatment sites with long or complex streams.

Crew camps would include temporary installations (food storage and equipment lockers) which could be in place for 6 to 10 years per site at physical treatment sites, and 1 to 2 years per site at piscicide sites. These would be removed after project work is completed at each site.

There could be up to three flights per restoration site per year. Flights would occur at mobilization to deliver supplies, at demobilization to remove supplies and materials from the project site, and to transport frogs to distance reintroduction sites. Flights would be of short duration and would only be used if stock could not be used to transport supplies to a given project site (e.g. if the trails are not suitable or safe for stock, or if the equipment is too heavy, fragile, or bulky for stock to carry) or if translocation sites are longer than a 6 hour hike. The adverse effect is temporary, generally only when the helicopter is en route and for 15 to 30 minutes at the landing areas, and would occur in several locations in wilderness each summer.

Project work would occur in selected areas of the wilderness over the 25 to 35 year life of the project. None of these developments would be permanent, and no permanent improvement or modern human occupation would occur at any of the restoration sites.

Opportunities for Solitude or Primitive and Unconfined Recreation: During any given year throughout the 25 to 35 year project, this alternative results in one to six temporary crew camps in the wilderness. Typically this is expected to be some combination of two to three crews conducting physical restoration concurrent with one or two crews conducting piscicide restoration, with a total of up to four crews in the wilderness at any one time (the crews may move from camp to camp during the field season). The crews implementing physical treatment would involve two to three workers per site. The crews would combine to treat areas with piscicides, and this would involve 8 to 15 people per site. Crews would camp up to 10 days per site visit and each site would be visited up to 7 times per season. These larger crews would be slightly more intrusive in frequently used areas, but the larger camps would only be needed for 2 weeks during the actual treatment. Most of the treatment locations are away from popular visitor use areas; however there is still the likelihood that wilderness users could use the same areas, resulting in a short-term adverse effect on opportunities for solitude.

The use of helicopters would reduce opportunities for solitude as it would affect the natural soundscape on a short-term basis. If visitors are directed to avoid sites during helicopter drops of equipment, then there would be a temporary reduction in opportunities for unconfined recreation. This would occur for the 15 to 30 minutes required to off load or load equipment, so the adverse effect would be negligible and short-term.

There would be long term adverse effects on opportunities for primitive recreation (e.g. angling) resulting from reduced angling opportunities at 87 of the parks' waterbodies and 41 miles (66 km) of streams. But 84% of the 549 lakes and streams containing nonnative fish would continue to provide angling opportunities in the long-term. There would be long-term beneficial effects from the restoration of healthy native ecosystems at treated sites, leading to enhanced opportunities for primitive recreation related to the viewing of native wildlife and natural ecosystems.

If area closures occur due to piscicide treatments, then there would be reduced opportunities for unconfined recreation. These area closures would be limited to the project area, and would be at most for 3 days per treatment, resulting in adverse effects on opportunities for unconfined recreation.

Other Features of Value: No effect.

Effects to safety: Carrying heavy, fragile, and large equipment from stock drop off points to project sites would pose an increased safety risk to project crew members. Helicopter operations are inherently risky. Prior to considering whether to use helicopters, the previous criteria would be reviewed. This alternative would be less risky to the on-ground crews as they would not be required to carry in the heavy, fragile, and bulky equipment to and from the project area to the stock drop-off location, over trail-less areas with rugged topography.

Due to the remoteness of the proposed project areas, the distance to any downstream human population, and the low likelihood of exposure to visitors during and after treatment, there would be a low risk of human exposure to the piscicides (outside of the crews conducting the treatments), and little threat to the health and safety of wilderness users and the parks' neighbors. Employees would be exposed to piscicides but this risk would be mitigated through proper training and following established protocols.

Effects to other criteria (e.g., special provisions, economics, timing constraints, traditional skills, weather, visitation, etc.): Time of year and weather are considerations when planning project activities, and are considered when determining if a helicopter or stock crew would be utilized to transport equipment to the project site. If it is not possible to use stock to access a camp location, then a helicopter is considered for mobilization/ demobilization. This would allow work at project sites to be started earlier in the season, and extend later into the fall, allowing the project objectives to be met at a quicker rate.

Alternative # __3___ Physical Treatment Preceding Restoration – Including 4(c) activities (*No Piscicide Use)* – installation of gill nets, fish traps, and camp crews; blasting to create barriers; use of helicopters for transportation of equipment

Description:

Alternative 3 would use physical treatment methods only to eradicate nonnative fish by electrofishing, gillnetting, disruption or covering of redds, and blasting rock to create vertical fish barriers. In comparison to alternative 2, excluded from the list of proposed restoration waters are long reaches of stream, most large lakes, and interconnected lake complexes that are too large or too complex for effective physical treatment. Therefore, alternative 3 would not meet the project objective to restore large, deep, and /or cold waterbodies that can buffer drying and warming trends in the face of climate change.

Physical treatment would be used for 49 waters (26 lakes, 22 ponds, 1 marsh; total of 483 acres) and approximately 14 miles of stream in 15 basins. In addition, any fish-containing habitat adjacent to treated lakes, ponds and stream sections would also require treatment in order to eradicate fish from each restoration area. Although the total acreage requiring treatment may change slightly based on site-specific survey information and prescription development, the number of waters and stream miles identified for treatment represents the maximum number of waters to be treated in this alternative, and may be reduced as basin prescriptions are completed.

Blasting may be necessary under this alternative in areas where inadequate fish barriers exist. Although the goal of the treatment site selection is to select basins with adequate downstream barriers that prevent fish movement between treated and untreated waters, sometimes a barrier is later (post treatment) found to be inadequate to prevent fish from moving upstream into treated waters.

Location of Proposed Treatments
Aquatic ecosystem restoration would take place in 38 basins. Nonnative fish would be eradicated using physical methods only from 49 waters in 15 basins, including 48 lakes and ponds (481 ac), 1 known fish-containing marsh area (2 ac), approximately 14 miles of streams, plus additional connecting fish-containing habitat as necessary. These 49 waters represent 9% of the parks' approximately 549 waters known to contain nonnative fish that are candidates for eradication. Fishless habitat important for conservation of MYLFs and other native species would be managed in the 15 fish eradication basins, plus 25 additional basins where no fish eradication would occur.

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Basin	# Lakes	Area (ac)	# Ponds	Area (ac)	Stream (mi)
Physical Treatment Only					
Barrett	3	43.37	1	0.24	0.44
Blossom	2	9.98	2	2.05	1.01
Brewer	0	0.00	1	2.18	0.49
Crytes	2	20.62	1	0.87	0.02
Dusy	1	10.58	2	0.60	0.69
East Wright	1	2.63	0	0.00	0.66
Horseshoe	4	27.26	0	0.00	0.93
McGee	4	75.31	4	1.19	0.99
Milestone	1	12.80	1	2.07	0.49
Rambaud	0	0.00	1	0.38	0.79
Tablelands	0	0.00	1	1.37	1.48
Upper Bubbs	2	21.12	2	1.48	3.68
Upper Evolution	4	228.19	1	0.48	1.46
Upper Kern	0	0.00	2	2.12	0.38
Vidette	2	14.66	3	0.20	0.44
Grand Total	**26**	**466.51**	**22**	**15.23**	**13.94**

Components of the Action		**Activity for this Alternative**
1	Transportation of Personnel to and from the Project Site	Crews hike to and from project sites.
2	Transportation of Equipment to and from the Project Site	Stock or helicopters would be used for mobilizations and demobilizations of physical treatment sites per criteria detailed in Alternatives 1 and 2. Stock would be used for two round trips per site, 1 to 2 sites per year. In general, site mobilizations require 5 animals and demobilizations require 3 to 4 animals. The maximum yearly stock use is estimated to be 8 to 9 animals per site, requiring only one overnight stay per trip. Therefore, the maximum number of expected stock nights (number of animals multiplied by nights) per year generated by any of the project alternatives is estimated at 16 to 18 nights. A helicopter would be used for transporting materials to project areas based on the previously described criteria.
3	Establishment of and Use of Crew Camps	Crew size is typically 2 to 3 crewmembers. Crews would camp up to 10 days per site visit and each site would be visited up to 7 times per season. Physical restoration generally takes 6 years per lake and up to 10 years per stream and marsh area. Crew camps include a short-term installation of food and equipment storage lockers which would

		be left in place for the duration of the project work, and removed once the project work is completed.
4	Fish Capture Techniques and Tools	Gill nets, electrofishers, fish traps, and disruption of redds
5	Translocation Methods	Frogs to be translocated are either hiked to nearby recipient habitat or transported by helicopter to distant recipient habitat. ‘Nearby’ habitat generally can be hiked to within 6 hours, posing minor risk to frog survival during transport. ‘Distant’ habitat cannot be hiked to within 6 hours, which would pose moderate to high risk to frog survival during transport. At the recipient site, all individuals would be released into fishless habitat and monitored for the next several years.
6	Stream barriers	There may be up to five stream barriers constructed under this alternative, created by blasting rock at the downstream end of a cascade to create a vertical waterfall unbreachable by fish. Temporary net stream barriers would not be used since that is only associated with piscicide use.
7	Condition of Site After Project	Natural processes in wilderness would be restored to a more limited extent compared to Alternative 2, by eliminating impacts being caused by self-sustaining nonnative trout populations in 49 waters and 14 miles of streams, plus connected fish-containing habitat as necessary. However, there would still be self-sustaining nonnative trout populations present in approximately 500 waters plus connecting streams. This alternative represents 9% of the parks’ approximately 549 waters known to contain self-sustaining nonnative trout populations. A total of 38 basins would be restored to a more natural condition under this alternative. Blasting - Up to five sites would be permanently altered by blasting actions.

Effects to Wilderness Character:

Untrammeled: The trammeling activities associated with alternative 3 include removing nonnative fish by physical methods (gill netting, fish traps, and electrofishing) and blasting a permanent physical barrier in up to five streams – all of which are intentional manipulations of the wilderness. Overall, when compared with alternative 2, there would be fewer treated sites, but because physical treatment requires longer time periods, the trammeling actions would occur for the next 25 to 35 years. Physical treatment would be used for 38 basins, 49 waterbodies (26 lakes, 22 ponds, 1 marsh; total of 483 acres) and approximately 14 miles (22 km) of streams contained in 15 basins. Up to five sites would be treated each year for the next 25 to 35 years. Treatment per site could occur for approximately 6 years for lakes and ponds, and up to 10 years for sites with long or complex streams. Active work by crews would occur during the summer, but nets would be set during the winter in select locations in deeper waters to continue to capture fish.

Blasting rock to create vertical fish barriers at five locations is an intentional manipulation of the stream substrate that is meant to control nonnative fish movement. Treatment sites are selected based on the presence of a downstream barrier. However, sometimes the downstream barrier is not effective for preventing nonnative fish from traveling upstream to a previously treated area. If this occurs, and nonnative fish cannot be removed from the downstream areas using physical methods (e.g. gill netting, electrofishing, or fish traps) because it the lake area is too big, too complex, or the streams are too long, then a barrier would need to be created. This barrier would have to prevent nonnative fish from moving upstream, while allowing for the continued flow of water. Blasting is considered the best way to create a barrier as it would involve using natural elements and long-term maintenance would not be required, versus putting in a concrete or human-made structure which would require periodic maintenance, would change the flow of water, and would be a long-term development in the wilderness. Blasting a stream barrier would result in a long-term manipulation of the biophysical environment and would result in a permanent modification/trammel of the stream.

Natural: Under this alternative, there would be approximately 500 waterbodies continuing to contain self-sustaining nonnative trout populations, which have a long-term adverse effect on the natural quality of wilderness. Aquatic ecosystem restoration would occur over the next 25-35 years in 40 basins, described as follows. Physical fish eradication treatments would be used for 49 waterbodies (26 lakes, 22 ponds, 1 marsh; total of 483 acres) and approximately 14 miles of streams contained in 15 basins. In comparison to alternative 2, excluded from the list of proposed fish eradication waters are long reaches of stream, most large lakes (which are more resilient to climate change), and interconnected lake complexes that are too large or complex for effective physical treatment. Fishless habitat important for conservation of MYLFs and other native species would be managed in the 15 fish eradication basins, plus 25 additional basins where no fish eradication would occur.

The 49 waterbodies to be treated under this alternative represent 9% of the parks' approximately 549 waters known to contain self-sustaining nonnative trout populations that are candidates for fish eradication. A total of 40 basins would be restored to a more natural condition under this alternative.

In addition, blasting rock would occur at no more than five individual cascade locations, and would modify the natural rock substrate beneath small sections of streams in these locations, resulting in a long-term adverse effect on the natural quality of wilderness. It is likely in the future that high water events, erosion, and normal geologic processes would remove the barrier that was created by the blasting, however, this would still constitute a long-term adverse effect on the natural quality of wilderness.

Undeveloped: Under this alternative, the undeveloped quality of wilderness would be affected by the use of gill nets (installations) during project work. There would be up to five temporary crew camps in wilderness per year, generally occupying each site for several weeks each season for approximately 6 years per site for lakes and ponds, and up to 10 years for sites with long or complex streams. Crew camps would include temporary installations (food storage and equipment lockers). These would be removed after project work is completed at each site. Project work would occur in selected areas of the wilderness over the 25 to 35-year life of the project. The result is a long-term adverse effect on undeveloped. None of the development would be permanent, and no permanent improvement or modern human occupation would occur at any of the restoration sites.

In addition, blasting rock at no more than five individual cascade locations would create permanent scars on rock beneath small sections of streams in these locations. The modification of the rock by blasting would result in a long-term adverse effect on the undeveloped quality of wilderness. It is likely in the future that high water events, erosion, and normal geologic processes would remove the evidence of the barrier created by blasting, and it is also highly likely that the blasted area would not be noticeable to wilderness visitors as for most of the year it would be under water or snow; regardless of this, it is still considered a long-term adverse effect on the undeveloped quality of wilderness.

Helicopter use would be similar to alternative 2, however, there would be fewer project sites, and therefore reduced adverse effects on the undeveloped quality from the use of a helicopter when compared to alternative 2. There could be up to three flights per restoration site per year. Flights would occur at mobilization to deliver supplies, and at demobilization to remove supplies and materials from the project site. Flights would be of short duration and would only be used if stock could not be used to transport supplies to a given project site (e.g. if the trails are not suitable or safe for stock, or if the equipment is too heavy, fragile, or bulky for stock to carry). The adverse effect is temporary, generally only when the helicopter is en route and for 15 to 30 minutes at the landing areas, and would occur in several locations in wilderness each summer.

Opportunities for Solitude or Primitive and Unconfined Recreation: During any given year throughout the 25 to 35 year project, there would one to five crew camps in wilderness each year. The crews implementing physical treatment would involve two to three workers per site, occupying each site for several weeks each season. Most of the treatment locations are away from popular visitor use areas; however, wilderness users could use the same areas and be adversely affected by the loss of solitude.

There would be long-term adverse effects on opportunities for primitive recreation (e.g. angling) resulting from reduced angling opportunities at 49 of the parks' waterbodies and 14 miles (22 km) of streams. However, there would be long-term beneficial effects from the restoration of healthy native ecosystems at treated sites, leading to enhanced opportunities for primitive recreation related to the viewing of native wildlife and natural ecosystems.

There would be no area closures associated with this alternative and no affect to opportunities for primitive and unconfined recreation.

Other Features of Value: No effect.

Effects to safety: As stated under alternative 2, helicopter operations are inherently risky. Prior to considering whether to use helicopters, the previously identified criteria would be reviewed. The on-the-ground elements of this alternative are similar to the no action (continuing the current project). There are no effects to safety out of the ordinary. All project work would require the preparation of Job Hazard Analyses.

Effects to other criteria from Elements Common to All Alternatives (e.g., special provisions, economics, timing constraints, traditional skills, weather, visitation, etc.): Actions would need to occur during summer months to allow for travel into the SEKI wilderness when conditions are appropriate (little or no snow and ice).

Alternative # __4___ Piscicide Treatment Preceding Restoration – with limited 4(c) Actions – Piscicide Use and Helicopter Use for transport of equipment; no physical treatments (no gill nets, electrofishing, or fish traps); limited and short-term installations related to crew camps; and temporary fish barriers (no blasting)

Description:

Properly applied, piscicides can eliminate fish from targeted waters in as few as 1 to 2 days per site, in contrast to physical treatment methods which can take up to 6 years for lakes and up to 10 years for streams (NPS 2012). Based on initial examination of maps, staff familiarity with the park, and discussions with scientists, piscicide treatment would be used for 87 waters (32 lakes, 50 ponds, and 5 known fish-containing marshes; total of 708 ac), approximately 41 miles of streams, plus additional connected fish-containing habitat as necessary. Although the total acreage requiring treatment may change slightly based on site-specific survey information and prescription development, the number of waters and stream miles identified for treatment represents the maximum number of waters to be treated in this alternative, and may be reduced as basin prescriptions are completed.

Location of Proposed Treatments
Aquatic ecosystem restoration would take place in 41 basins. Nonnative fish would be eradicated using piscicide methods from selected waters in 20 basins, including 82 lakes and ponds (676 ac), 5

associated fish-containing marsh areas (32 ac), approximately 41 miles of stream, plus additional connected fish-containing habitat as necessary. These 87 waters represent 16% of the parks' 549 waters known to contain nonnative fish that are candidates for eradication.

Fishless habitat important for conservation of MYLFs and other native species would be managed in the 20 fish eradication basins plus 21 additional basins where no fish eradication would occur.

Basin	# Lakes	Area (ac)	# Ponds	Area (ac)	Stream (mi)
Piscicide Treatment Only					
Amphitheater	1	58.87	2	1.34	2.16
Barrett	3	43.37	1	0.24	3.10
Blossom	2	9.98	2	2.05	1.01
Brewer	0	0.00	1	2.18	0.49
Crescent	0	0.00	0	0.00	3.98
Crytes	2	20.62	1	0.87	3.39
Dusy	1	10.58	2	0.60	0.69
East Wright	1	2.63	0	0.00	0.66
Horseshoe	4	27.26	0	0.00	0.93
Laurel	0	0.00	1	0.22	4.98
McGee	4	75.31	4	1.19	0.99
Milestone	1	12.80	1	2.07	0.49
Rambaud	0	0.00	1	0.38	0.79
Sixty Lake	1	12.94	16	14.56	1.84
Slide	1	5.12	0	0.00	4.13
Tablelands	1	76.77	2	2.94	2.24
Upper Bubbs	2	21.12	2	1.48	4.48
Upper Evolution	4	228.19	1	0.48	2.17
Upper Kern	2	18.32	10	6.29	1.85
Vidette	2	14.66	3	0.20	0.44
Grand Total	**32**	**638.53**	**50**	**37.10**	**40.81**

Components of the Action		**Activity for this Alternative**
1	Transportation of Personnel to and from the Project Site	Crews hike to and from project sites.
2	Transportation of Equipment to and from the Project Site	Because the equipment is fragile and heavy, and includes liquids, all equipment would be transported by helicopter.
3	Establishment of and Use of Crew Camps	Crew size would be 8 to 15 crewmembers at piscicide worksites. Crews would camp up to 10 days per site visit and each site would be visited up to 2 times per season. Restoration using piscicides would be expected to take 2 to 4 weeks in each of 1 to 2 years per site. Since crews would occupy sites for a short period of time, no food storage locker would be needed.
4	Fish Capture Techniques and Tools	Piscicides only
5	Translocation Methods	Frogs to be translocated are either hiked to nearby recipient habitat or transported by helicopter to

		distant recipient habitat. 'Nearby' habitat generally can be hiked to within 6 hours, posing minor risk to frog survival during transport. 'Distant' habitat cannot be hiked to within 6 hours, which would pose moderate to high risk to frog survival during transport. At the recipient site, all individuals would be released into fishless habitat and monitored for the next several years.
6	Stream barriers	A temporary fish barrier would be installed if needed to protect an invertebrate source population from fish recolonization until fish are eradicated with piscicides. No permanent barriers would be created.
7	Condition of Site After Project	In 15 to 20 years, project objectives would be accomplished. There would be 82 lakes and ponds, 5 associated marshes, approximately 41 miles (66 km) of streams, and connected fish-containing habitat (as necessary) restored to natural conditions, which is 16% of the 549 waterbodies known to contain nonnative fish that are candidates for eradication. Invertebrates would be eliminated at the piscicide treatment sites until recovery occurs. The recovery of invertebrates (thus the restoration of the natural quality) at the treatment sites could take 5 years or more (Mangum and Madrigal 1999).

Effects to Wilderness Character:

Untrammeled: Under this alternative, the short-term adverse effects as a result of trammeling due to the use of piscicides to eradicate nonnative fish from 82 lakes and ponds (676 ac), 5 associated fish-containing marshes (32 ac), approximately 41 miles (66 km) of streams, plus connected fish-containing habitat as necessary, would create more impacts on untrammeled than the other alternatives.

At any given time during the summer, there could be up to six piscicide projects ongoing, including up to two sites with treatment activities (applying piscicide) and up to four sites with pre- or post-treatment assessment activities (collecting invertebrate samples in the summers before and after each treatment). Treatment sites would be occupied for 2 to 3 weeks each year; assessment sites would be occupied for 1 to 2 weeks each year. The actual piscicide treatment would occur over a period of 1 to 2 days.

Because piscicide treatment, if done properly and under the correct environmental conditions, can result in the elimination of nonnative fish from targeted waterbodies in as few as 1 to 2 days, the trammeling actions would be completed sooner than the other action alternatives. Therefore, the overall project would be completed in the wilderness in a shorter period of time (the trammeling actions would stop in 15 to 20 years as opposed to 25 to 35 years as in other alternatives). Overall, when considering the scale and timing of this project, the adverse effects on trammeling would be long-term for the duration of the project.

Natural: Under this alternative, there would be 462 waterbodies continuing to contain self-sustaining nonnative fish populations, which is a long-term adverse effect on the natural quality of wilderness character. Piscicide use would be utilized to remove nonnative fish over the next 15 to 20 years in 20 basins, including 82 lakes and ponds (676 ac), 5 associated fish-containing marshes (32 ac), approximately 41 miles (66 km) of streams, plus connected fish-containing habitat as necessary. Nonnative fish would be removed from 16% of the parks' 549 waterbodies known to contain nonnative fish that are candidates for eradication.

As described in detail under Alternative 2, there would be an adverse effect on the natural quality of wilderness from the use of piscicides (see alternative 2 for a full description of the effects of piscicides). Piscicides would kill most gill breathing organisms in the waters where they are used. The recovery of invertebrates (thus the restoration of the natural quality) at the treatment sites could take up to 5 years or more (Mangum and Madrigal 1999). However, this alternative would effectively restore the natural quality of wilderness at the treatment sites at a more rapid rate than the other alternatives, resulting in long-term beneficial effects.

Undeveloped: The use of a small electric pump associated with piscicide use creates a short-term adverse effect on the undeveloped quality of wilderness. In addition, there would be a short-term adverse effect from the use of nets as barriers across streams between treatment sites. There would be up to six temporary crew camps in wilderness per year and some of these may have temporary installations (camping equipment). Because the projects would be of short duration, there would be no food storage lockers or equipment lockers needed. Treatment sites would be occupied for 2 to 3 weeks in the summer for up to 2 years per site; assessment sites would be occupied for 1 to 2 weeks in the summer for up to 4 years per site.

Project work would occur in selected areas of the wilderness over the 15 to 20 year life of the project, so the overall effect on the undeveloped quality would be long-term. None of the development would be permanent, and no permanent improvement or modern human occupation would occur at any of the restoration sites.

Opportunities for Solitude or Primitive and Unconfined Recreation: Under this alternative, there would be up to six crews each year working in the wilderness, including up to two treatment crews and up to four pre- or post-treatment assessment crews. Each treatment crew would occupy a selected project site for 2 to 3 weeks during treatment activities; each assessment crew would occupy a selected project site for 1 to 2 weeks during assessment activities. Treatment crews would generally involve 8 to 15 people per site; assessment crews would generally involve 2 to 4 people per site. Most of the treatment locations are away from popular visitor use areas; however wilderness users could use the same areas and be adversely affected by the loss of solitude.

There would be long-term adverse effects on opportunities for primitive recreation (e.g. angling) resulting from reduced angling opportunities at 87 of the parks' waterbodies and 41 miles (66 km) of streams. But 84% of the 549 lakes and streams containing nonnative fish would continue to provide angling opportunities in the long-term. There would be long-term beneficial effects from the restoration of healthy native ecosystems at treated sites, leading to enhanced opportunities for primitive recreation related to the viewing of native wildlife and natural ecosystems.

There would be reduced opportunities for unconfined recreation because the treatment areas would be closed to visitors during and for three days after the piscicide application.

Other Features of Value: No effect.

Effects to safety: The risk from the use of helicopters would be the more than the other alternatives, as there would be more transportation flights required to deliver the piscicides to all the treatment locations. The risk associated with the use of piscicides to project crews would be greater as all the areas would be treated with piscicides. However, overall this alternative results in less exposure to environmental hazards associated with using gill nets and electrofishers (e.g. cold water, slippery rocks and streams, camping and living in high elevation wilderness conditions, etc.). Crews would be spending less time in the waterbodies conducting treatment actions. The project implementation period would be reduced to a maximum of 20 years.

Due to the remoteness of the proposed project areas, the distance to any downstream human population, and the low likelihood of exposure to visitors during and after treatment, there would be a low risk of human exposure to the piscicides, and little threat to the health and safety of wilderness users and the parks' neighbors.

Effects to other criteria (e.g., special provisions, economics, timing constraints, traditional skills, weather, visitation, etc.): Alternative 4 emphasizes speed in recovering habitat because MYLF populations are declining very rapidly and are at a high risk from extinction. To achieve this speed, only piscicide treatment would be used for nonnative fish eradication.

Mitigation Measures for Action Alternatives (where applicable)

Work Crews (all alternatives)

- All crews would be instructed in and expected to use minimum impact camping practices and wilderness ethics.
- Crew camps will be located where they have minimal impact on opportunities for solitude and primitive and unconfined recreation and the natural qualities of wilderness character. Generally, existing camps frequently used by the public will be avoided, but will be used if adequate naturally hardened sites are not available. Naturally hardened sites have a natural abundance of sand, gravel, or rock and a natural lack of grasses and forbs. Where possible, crew camps would be located at base camps used for previous projects, with minimum potential to disrupt wildlife habitat or habits.
- Crews would be instructed on proper food-storage practices and camps would be inspected to make sure food is properly stored.
- Water for the crews both at work sites and in camp would be taken from a stream or lake that would be accessed by non-sensitive paths. The crews would be instructed to avoid sensitive areas in both the work sites and crew camp areas.
- Gray water would be disposed of over 100 feet from any surface water and would be poured into a small pit through a screen to remove small food particles, which would then be removed from wilderness with other trash.
- Special containers or pit toilets would be used for toilets in all work and camp areas. The containers would be packed or flown out at the end of the field season and disposed of in a sewage treatment facility.
- No motorized equipment would be used in camp. A propane/white gas or battery-powered lantern or headlamp would be used to light the work and cooking area inside the work tent. All other light would be from personal flashlights and headlamps.
- All equipment, clothing, and gear would be checked for debris, cleaned of any visible plant or soil matter, and disinfected with quaternary ammonia following SEKI's disinfection protocol prior to moving to a new site.

Stock Use (all alternatives)

- SEKI's packstock operations would be subject to minimum impact standards and grazing regulations per SEKI's SOPs.
- Packstock (fur and hooves) and equipment would be inspected and cleaned of seeds and dirt, as necessary, before leaving the front country.
- All SEKI grazing restrictions and regulations would be adhered to. California certified weed-free cubes, grain, or weed-free hay would be fed to stock at wilderness areas where grazing is not allowed.

Helicopter Use (for applicable alternatives)

- If a helicopter is determined to be the minimum tool, then a temporary landing zone would be established at the project site. The landing zone should be void of trees and boulders that could pose a threat to helicopter rotors; should be on flat, level surface; minimal exposure to heavy winds; sites with ease of landing (affects load weights that can be delivered); and in proximity to base camp.

- A trained helicopter crewmember would be present at the work area to direct air operations, handle cargo and ensure public and employee safety.
- Except in the case of a medical emergency, flights would occur only between 8:00 a.m. and 5:00 p.m. and would follow flight paths to and from the project sites designed to avoid sensitive areas.
- Park trailhead staff would inform hikers of possible noise intrusions, when they would occur, and alternative routes visitors could use to avoid the noise.
- Park staff would inform visitors camping near the project sites and landing areas of flights and project activities.

Vegetation

- If species of concern are present in work and camp sites, appropriate mitigation measures would be taken, which could include collecting seed or flagging areas during project work to protect the species from onsite activities.
- Equipment and materials would be inspected for soil and plant parts. Dirty materials would be cleaned before being transported to field sites. Equipment and materials that could acquire seeds from surrounding areas would be covered during transport.
- A list and / or map of project areas would be maintained so that sites can subsequently be surveyed for invasive nonnative plants.
- Work crews would inspect their shoes, clothing and equipment for seeds and soil before leaving the front country. Seeds and soil would be removed and placed in bagged garbage.

Wildlife

- Crew camps would be located at least 100 ft (30 m) away from aquatic habitat for MYLFs, Yosemite toads, and Little Kern golden trout, and away from ridgeline habitat for bighorn sheep.
- Stock would be kept at least 100 ft (30 m) away from 1) the core aquatic habitat for MYLFs, Yosemite toads, and Little Kern golden trout; and core terrestrial habitat for bighorn sheep.
- Little Kern golden trout occur in one proposed treatment area (Crytes Basin; NPS unpublished data) included in this plan. This population is not native to Crytes Basin, is not part of the official recovery plan for the species (Christenson 1984), and recent genetic analysis shows that this population is not genetically-pure (Deiner et al. 2010, Erickson et al. 2010). Although this population is not genetically-pure, it still may have value in that it retains some amount of Little Kern golden trout alleles. If this population was determined to be useful as brood stock for management and restoration of Little Kern golden trout within the recovery plan area, SEKI would work with CDFW to live-capture and move as many fish as possible to an appropriate location outside of the project area.
- Prior to any approved helicopter flight, the parks' wildlife biologist would provide a map of known bighorn sheep areas, and the helicopter would avoid flying above or landing in those areas; the final approach to the landing zone would stay below the area of the historic sightings. Flights would be suspended if sheep are observed within ½ mile (0.8 km) of the project area. The landing zone for the helicopter would be located approximately 500 ft (152 m) from any area where sheep have been observed.

Water Quality

- Equipment and materials would be stored at least 100 ft (30 m) from open water to reduce the likelihood of debris or sediment entering surface water.
- Spilled hazardous materials (e.g. piscicide or white gas) would be cleaned up immediately and would not be allowed to seep into the soil or reach open water sources.
- Work crews would use appropriate methods for human waste treatment, which is typically a pit toilet, or special containers for removal to the frontcountry.

Soundscapes

- To minimize visitors' exposure to unnatural sounds, project work would typically occur from 8:00 a.m. to 5:30 p.m.
  - Crew leaders would ensure that the crew's noise levels do not disturb nearby campers.
  - Information may be attached to wilderness permits to advise wilderness users about the need for management action and locations of work activities during their visit to the SEKI wilderness.

Cultural Resources

- Should any unknown cultural resources be encountered during implementation of plan activities, all ground disturbance will be immediately stopped. The parks' archeologist or a qualified representative will examine the area as soon as possible and will follow the requirements of the *National Historic Preservation Act,* and any other applicable cultural resource laws, as needed.

Visitor and Crew Safety

- Crews would be instructed in backcountry safety issues and wilderness communication protocols at the beginning of each field season; they would be provided with radios, and have an established, regular call-in time.
- Crews would abide by the RMS Safety Plan.
- Visitor use could occur in the restoration areas. Any visitors in active restoration areas would be met by a crewmember and kept a safe distance from restoration activities.

The mitigations for specific types of treatment options are described below. These mitigations will be implemented based on the methods selected in the final plan.

Gill Netting (for applicable alternatives)

- Crewmembers would be trained to always scan nets for non-target wildlife (primarily birds) when walking along shorelines to allow for a captured animal to be detected and released before mortality has occurred.
- The shore ends of nets would be set 3 to 10 ft (1 to 3 m) from shore to provide a buffer for non-target animals to access shoreline habitat.

Electrofishing (for applicable alternatives)

- Crewmembers would wear waterproof chest waders and gloves that do not conduct electricity.
  - Crewmembers would wear wading boots with felt-lined soles that provide improved stability. The output from electrofishers is engineered to specifically target fish so non-target species are much less affected by electrofishing. Felt-soled boots used for project work would only be used at project sites. Boots would remain at each project site for the summer, and would be transported out of the project area for the winter, where they would be decontaminated before their next use. This process would eliminate the potential to sustain or transport undesirable nonnative species.

Disruption of Redds (for applicable alternatives)

- Crewmembers wear wading boots with felt-lined soles that provide improved stability.

Fish Traps (for applicable alternatives)

- While installing and monitoring fish traps, crewmembers wear wading boots with felt-lined soles that provide improved stability, and gloves to protect their hands while working with the traps.

Blasting of Rock to Create Vertical Fish Barriers (for applicable alternatives)

- The NPS would complete site-specific plans for each proposed blasting location, consulting with the SEKI hydrologist for final review. The areas would be surveyed for natural and cultural resources and all applicable state and federal permits would be obtained prior to any stream modification. This surveying and permitting would be completed on a case-by-case basis before blasting activities begin.

- Parks staff involved in blasting activities would wear appropriate PPE (eye, ear and hand protection) and perform their working according to SEKI's blasting procedures. Charges are activated using detonation cord, allowing staff to position themselves safely away from the blast area.

Piscicide Use (for applicable alternatives)

- In piscicide treatment areas with extant MYLF populations, mitigations include capturing as many individuals as possible and moving them to adjacent untreated waterbodies before piscicide treatments are conducted. Most, but not all, of the MYLFs in the treatment areas are expected to be captured and moved out of treatment areas.
- If adequate fishless habitat is not present at the head of streams to provide upstream source populations of invertebrates for repopulating treated areas, then a section of stream would be physically treated to remove fish and create an upstream source population. A temporary fish barrier would be installed if needed to protect a source population from fish recolonization until fish are eradicated with piscicides.
- The state of California requires that pesticide applications be managed by trained and certified applicators. At least one member of the onsite piscicides application crew would be certified by the state of California as an applicator and all of the restoration crew working with piscicides would be trained in proper use of personal protective equipment, product safety measures, and they would operate under the direction of the certified applicator(s) and in accordance with project safety plans or job hazard analysis.
- Application of rotenone would be carried out in a manner that strictly adheres to practices permitted by the product labeling, including use of personal protective equipment (PPE) for applicators, controlling public access during application, determining the maximum necessary application concentrations, and all other applicable guidelines.
- Rotenone drip stations would be placed in secure and stable locations either on the stream bank or on a stand in the stream channel, and are actively monitored by project staff for the duration of the treatment. The drip nozzles of the stations would be placed very close to the water's surface to reduce the potential for piscicide drift to terrestrial environments. Rotenone applied from backpack sprayers is applied with the spray head very close to the water surface to minimize drift onto terrestrial environments.
- Fish would be collected prior to the treatment process from the project area and placed in net baskets just downstream of drip stations to monitor the effectiveness of the piscicide treatment.
- Rotenone would be neutralized by the careful addition of potassium permanganate to the water at established locations. Fish baskets would also be placed downstream of the neutralization station. Mortality of these fish would alert workers to potential releases of excess chemical in the event of human or equipment error and potential downstream effects.
- Treated fish that do not sink would be removed from treated habitat to reduce short-term nutrient-loading, and scattered or buried in nearby terrestrial areas away from trails and campsites.
- During and after rotenone treatments, water quality would be monitored to assess the effects of treatment on surface waters and bottom sediments. The monitoring would determine that: 1) effective piscicide concentrations of rotenone are applied; 2) sufficient degradation of rotenone has occurred prior to the resumption of public contact; and 3) rotenone toxicity does not occur outside the project area. An analytical laboratory would analyze water samples for rotenone concentrations as well as for volatile organic compound and semi-volatile organic compound concentrations.
- The parks would also develop and implement a spill contingency plan that addresses chemical transport and use guidelines, as well as spill prevention and containment that adequately protects water quality. The spill contingency plan would be maintained on site.
- Piscicide containers would be securely locked or guarded when taken to the field for use.

- Any piscicide that is spilled would be scooped up (including top layer of soil) with a shovel, placed in a bag designed for product disposal, and transported out of area for disposal as required on the product label.
- Piscicide applications would be communicated to the public using 1) temporary information and warning signs posted on trails near the treatment area, 2) staff stationed on nearby trails, 3) visits to nearby campsites, 4) verbal contacts by the nearest wilderness rangers, 4) staff at local wilderness permit stations, 5) temporary postings to the parks website and 6) information attached to wilderness permits. Any area closures would be included in the annual updates to the Superintendent's compendium.
- Most of the piscicide applications would occur in areas that generally have little visitation. Nevertheless, prior to applications and throughout treatments, public access would be restricted through the use of signs located at trailheads and other strategic places.
- All personnel assisting in the fish removal would use hardened or durable sites for camping and would be familiar with and practice Leave-No-Trace (LNT) principles. A crew of 8 to 15 people is expected to be sufficient to implement each treatment. Trails would be used whenever possible to move from one location to another to minimize soil and vegetation disturbance and to prevent establishing new trails. Sensitive plant habitat will be avoided. Treatment activities would be coordinated with wilderness management personnel.

ALTERNATIVES CONSIDERED BUT DISMISSED

<u>"No Action" – No Restoration Program</u>
Under the "No Action" alternative, there would be no activities in the wilderness related to the aquatic ecosystem restoration program. All current activities would be halted. There would be no management of the high elevation aquatic ecosystems and no fish removal activities. The reason that this alternative was ruled out was due to the unacceptable adverse impacts to the natural quality of wilderness character. Natural conditions would remain altered by the presence of nonnative fish in 563 waterbodies throughout the SEKI wilderness. Many studies conducted in SEKI and elsewhere in the Sierra Nevada have researched the effects that nonnative trout have on native species and ecosystems. These studies consistently document that the widespread introduction and continued presence of nonnative trout has caused substantial impacts to native species and ecosystems. Because nonnative trout are efficient predators and competitors, their introduction results in modifications to native food webs; they prey on large organisms such as amphibians and large-bodied aquatic insects and zooplankton, and altering, depleting or eliminating populations of these animals from naturally fishless habitats. This results in less food being available to native aquatic and terrestrial predators, altering their distribution and abundance in turn. Thus, the presence of nonnative trout has negative, cascading effects on entire ecosystems, and their presence in individual lakes, connecting streams and entire lake basins in SEKI continues to cause negative impacts to native species and ecosystem processes. These impacts are replicated on a landscape scale across much of the parks' high elevations.

It is likely, without any action towards restoration, that the MYLF would be extirpated from the SEKI wilderness, creating a long-term adverse effect on the natural quality of wilderness. Not only have these species been detrimentally affected by nonnative trout, but the amphibian chytrid fungus (*Batrachochytrium dendrobatidis*) has been discovered in these parks. The fungus causes a highly infectious disease--chytridiomycosis--in many amphibian species. Studies indicate it recently spread into the Sierra Nevada (Rachowicz et al. 2005, Morgan et al. 2007; Vredenburg et al. 2010) and has infected nearly all remaining MYLF populations including those in SEKI and Yosemite National Park (YOSE). Most MYLF populations have severely declined within a few years after becoming infected and many populations have been extirpated. Chytrid fungus has thus been a major factor in accelerating the decline of MYLFs caused by nonnative fish throughout the Sierra Nevada. As a result, in 2007 the FWS reaffirmed the listing of the Sierra Nevada population of MYLFs as a "Federal Candidate Species" under the ESA (FWS 2003, 2007A). In 2012, the California Fish and Game Commission (CFGC) voted unanimously to list Rana muscosa as endangered and Rana sierrae as threatened under the California ESA (CFGC 2012). Without recovery and restoration actions, two native species would be permanently removed from the SEKI wilderness.

<u>Fish Eradication Using Biological Treatments</u>
An alternative to eradicate nonnative fish using tiger muskies was considered. The tiger muskie is a sterile hybrid-cross between a muskellunge and a northern pike. They have been effective at restructuring size classes of nonnative brook trout from mountain lakes in Idaho. However, they have been generally ineffective at completely eradicating unwanted fish species (IDFG 2010). Further, in a detailed analysis of 250 fish control projects, Meronek et al. (1996) found that stocking certain species of fish to control unwanted fish was the least successful method of fish removal compared to chemical, physical and reservoir drawdowns. Conceptually this technique had potential to be a cost-effective means of eradicating nonnative fish. However, in accordance with NPS Management Policies 2006, new exotic species will not be introduced into parks. In rare situations, an exotic species may be introduced or maintained to meet specific, identified management needs when all feasible and prudent measures to minimize the risk of harm have been taken (Section 4.4.4.1). The state of California also does not support any type of pike introduction. Once the nonnative fish have been eradicated, amphibians and large invertebrates would not be able to return until the predatory tiger muskies were gone. Although tiger muskies might starve after fish have been eradicated, they also might find sufficient natural food to persist. This alternative therefore has the potential to replace one problem (existing nonnative trout) with another (nonnative tiger muskies) and would be out of compliance with NPS Management Policies 2006.

The use of tiger trout, a sterile hybrid-cross between brown trout and brook trout, was also considered for nonnative fish eradication. It was dismissed for the same reasons as above for tiger muskies. For these reasons, biological treatments were dismissed from further consideration.

<u>Frog Restoration Using Only Captive Rearing and Reintroduction</u>
Implementing a MYLF captive rearing program for reintroduction into the wild is being considered as a restoration tool to supplement nonnative fish eradication and natural recolonization. The one method that has repeatedly strengthened remnant MYLF populations occupying fishless waters is eradicating nonnative fish in waters adjacent to existing populations and allowing frogs to naturally recolonize reclaimed habitat. Given the current distribution of nonnative fish and the size and isolation of MYLF populations, reintroductions would be necessary in proposed fish eradication waters that do not have adjacent MYLF populations. The best chance for restoring MYLFs therefore lies in reclaiming habitat through nonnative fish eradication 1) in waters adjacent to existing populations to allow natural recolonization to strengthen these populations, and 2) in basins where MYLFs once occurred to allow reintroductions to re-establish these populations.

Establishing a successful MYLF captive rearing program would provide a sustainable source of animals for reintroductions without jeopardizing existing wild populations. However, using only captive rearing and reintroduction to restore MYLFs in SEKI is not likely to achieve the objectives of this Restoration Plan/DEIS. It does not address the issues with fragmented populations and the availability of high quality habitat. And out of approximately nine recent MYLF reintroductions in SEKI and YOSE (NPS unpublished data), only two have established breeding populations (in YOSE). It will not be known for several years whether these populations become stable or die out. The causes for the low success rate for MYLF reintroductions are not currently known, however, research studies are being conducted to learn how to conduct reintroductions more successfully. In the meantime, it is not prudent to design a restoration plan that only uses a tool with a currently-low success rate. For these reasons, using only captive rearing and reintroduction to restore MYLFs was dismissed from further consideration.

<u>Fish Eradication Using Only Non 4(c) Actions – Angling or Covering Redds</u>
An alternative to eradicate nonnative fish using only angling (by NPS staff and the public) or by covering redds was considered. Removing fish by angling alone is not a proven way to completely eradicate fish from a waterbody, except possibly at sites where limited fish reproduction occurs within the lake or pond, and no fish reproduction occurs in adjacent streams. In the few locations where this situation exists, every single fish must eventually be attracted to some form of bait, lure or artificial fly, and then successfully caught and landed to shore by anglers. If all of the above criteria are satisfied, it would still take many years of sustained angling to remove all fish. In addition, not all of SEKI's fish containing waters are being proposed for nonnative fish eradication, and thus site restrictions would

need to be developed to ensure proposed waters were eradicated but other fish populations were not impacted. The management issues associated with recruiting, training and supervising multiple public anglers, all summer long for many years in a row, dispersed in designated wilderness, fishing only at approved waters, minimizing habitat damage, and protecting health and safety would be overwhelming. Finally, very few of the waters proposed for fish eradication meet all of the rare circumstances necessary for success, and thus restoration at the park scale would not be achievable using this alternative.

Covering or destroying redds is problematic to eradicate nonnative fish. Where redds are visible, destroying them would be possible. They can be broken apart and covered in lakes and streams. However, redds are not always visible. They can be deep in lakes or not clearly visible in streams. Locating redds for fish that spawn in the fall (brook trout) is particularly problematic because it would require crews to be in the high country from October to December (snow season), which would add significant health and safety issues for field crews. Furthermore, brook trout can spawn in marginal habitat that other trout (such as rainbow-golden hybrids) cannot, making their redds even more difficult to eliminate. Any redds that were missed would perpetuate the population, and persistent efforts to eliminate redds would result in natural selection for fish that spawn in the most difficult areas to locate.

<u>Fish Eradication using only Gillnets</u>
It is possible to eradicate fish from certain waters using only gill nets, but only if 1) there are no inlet or outlet streams attached to the water or 2) all attached streams are either inaccessible to fish or completely dry each summer. All of the proposed fish eradication basins, however, have waters with attached streams that would prevent successful eradication using only gill nets. Gill nets do not work well in streams since they rapidly collect floating debris or snag on submerged rocks or branches. It is not possible to eradicate fish from streams using only gill nets. At best, gill nets can be used for short periods in calm stream sections such as large pools. In addition, the presence of stream habitat within restoration areas is critical for restoring healthy MYLF populations because these species need streams to migrate between breeding, feeding and over-wintering waters. Limiting restoration to sites where fish can be eradicated using only gill nets would create restored “islands” that are isolated from one another. The waters feasible for this option are too scarce and isolated to facilitate effective restoration at the park scale.

<u>Fish Eradication by Temporarily Drying Stream Segments or Small Waters</u>
Theoretically, this would be a very effective way to eradicate fish and destroy any redds. Logistically, it would be extremely difficult to channel all of the water from one natural fish barrier to a point below the next downstream barrier, or to siphon all of the water out of a lake or pond faster than it could be replaced by water flowing from upstream areas. A break in the piping would be a disaster as huge quantities of water would flow over and erode upland areas. It would require potentially large temporary structures built in streams to divert the water and numerous equipment and personnel to move the pipe or conduit. This alternative could have extensive environmental impacts and be extremely impractical to implement. This option would not meet the wilderness management requirement of causing the least amount of impact to the physical resources and experiential qualities (character) of wilderness or using the least intrusive tools. Therefore it has been dismissed from further consideration.

<u>Fish Eradication Using the Piscicide Antimycin A</u>
There is another piscicide (antimycin A) that has been used to eradicate fish in national parks and other lands outside of California. However, antimycin A is not registered for use in California. Although SEKI may be able to apply for an exemption that could override state regulations because the proposed work is on federal land, park management decisions attempt to adhere to state regulations when a feasible option (rotenone) exists. Therefore, this alternative has been dismissed from further consideration at this time. If antimycin A or any other piscicide becomes available for use in California, NPS staff would assess the appropriateness of its use in SEKI to accomplish the purpose and goals of this plan. This assessment would include opportunities for public review and involvement, and would comply with existing laws, policies, and plans.

<u>Complete Eradication of Nonnative Fish (restoring the Natural) from All High Elevation Waters in Wilderness</u>

Complete eradication of nonnative fish populations from all high elevation waters in SEKI is neither practical nor feasible to be considered in this Restoration Plan/DEIS. At this time it is known that nonnative fish are present in approximately 549 lakes and ponds in SEKI that are candidates for eradication, and there may be additional populations in unmapped ponds and large stream pools that are far from all previously surveyed waters. In addition, there are many hundreds of miles of stream in which nonnative fish are present, ranging from the high elevation basins downstream to the low elevation unglaciated areas where native fish are also present. It is extremely unlikely that nonnative fish populations could be successfully eradicated from such an extensive and remote amount of habitat. If it was possible, it would be extremely difficult and expensive, and likely would take 50 to 100 years or more to complete, which is outside the duration of most or all plans under NEPA. Finally, complete eradication of nonnative fish from all high elevation waters would eliminate all high elevation angling opportunities in SEKI, which is not the intention of this Restoration Plan/DEIS. Therefore, this alternative has been dismissed from further consideration.

<u>Treating MYLF for Chytrid Fungus without Fish Removal</u>

The FWS, NPS, USFS, and California Department of Fish and Wildlife (CDFW) are currently collaborating on the development of a conservation strategy for the Sierra Nevada yellow-legged frog (R. sierrae) and the southern mountain yellow-legged frog (R. muscosa). The goal of the Conservation Strategy is to “Ensure self-sustaining long-term viability and evolution of mountain yellow legged frog populations in perpetuity that represent their historic geographical range, and genetic and ecological diversity.” The multi-agency team developing the strategy has concluded that eradicating introduced fish and developing methods for successful translocations are the primary tools available for recovering the species. MYLF must be protected in fishless habitat to survive. While treatment for chytrid fungus is being explored, the methods and techniques have only begun to be field tested, and there is no evidence that the methods will be successful in the long-term.

<u>Addressing other Known Stressors to MYLF and their habitat</u>

Stop Packstock Use in MYLF Habitat: Packstock use is permitted in SEKI wilderness. An extensive amount of long-term and ongoing monitoring data has been collected for SNYLF populations in SEKI and YOSE, which has made it possible to quantify impacts from packstock use. The vast majority of populations in SEKI and YOSE have received no to negligible impacts from packstock use. In populations where impacts were detected (Sixty Lake Basin in SEKI), packstock use is prohibited. In populations where impacts had reasonable potential to occur (upper LeConte Canyon in SEKI and Kerrick Meadow in YOSE), packstock use is regulated to prevent such impacts. In addition, packstock are adaptively managed in all areas of SEKI and YOSE, with many areas closed to stock entirely or limited to day use due to inadequate trail access or to protect sensitive habitat. In addition, it is documented that the two primary stressors to MYLF are nonnative fish (Bradford et al. 1993, Knapp and Matthews 2000, Vredenburg 2004, Finlay and Vredenburg 2007) and chytrid fungus (Rachowicz et al. 2006, Vredenburg et al. 2010). Without removing nonnative fish from MYLF habitat, and implementing the restoration MYLF program, solely closing areas to packstock would not result in the restoration of MYLF or high elevation aquatic ecosystems.

Halt Recreational Activities in MYLF Habitat: Reducing recreational activities in MYLF has been ruled out as a feasible alternative. First, it has been thoroughly documented that nonnative trout and disease pose the vast majority of risk to the conservation of the MYLF in SEKI, and thus “Fish Persistence” is the primary “manageable” risk factor for critical habitat in SEKI and YOSE.
Second, the NPS considers hiking/backpacking to be a negligible risk factor for MYLF conservation in SEKI. While hiking/backpacking occurs adjacent to many populations, there is evidence that the risk to nearly all proposed critical habitat in SEKI is slight to none. For example, in in SEKI, a high-use trail allows hikers annually numbering in the thousands to come into close contact with several MYLF populations, whose habitat is immediately adjacent to the trail. Repeated surveys show that these populations have grown substantially over the last decade (Knapp, unpublished data), indicating that hiking/backpacking is typically not a risk factor for critical habitat in SEKI.

Halt Livestock Grazing and Timber Harvest in MYLF Habitat: Neither is a permitted use in SEKI thus there would be no effect from this action.

<u>No use of Helicopters for Transport of Equipment</u>
The NPS considered not allowing the use of helicopters for project work, and using stock and humans to transport all equipment to the project site, or to a drop off point near the project site. There would likely be delays in project work. Project work would be limited to areas where snowmelt has occurred and conditions allow for stock transport, or project work would be delayed until access is safe and conditions allow for stock use. In addition – as much of the equipment is heavy, large, and/or fragile – it would be difficult and sometimes infeasible for humans to transport it by carrying it from stock drop-off points to project sites. There are safety concerns which would rule it out this option. Without the use of helicopters, it would be challenging and potentially dangerous for stock and/or crew members to carry heavy, bulky, and sometimes heavy liquid containers over steep rough terrain. Many of the project sites are in areas without trails and in high elevation environs where access is challenging. Therefore, some of the project work would not be possible, and the overall goals of this project would not be accomplished.

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Comparison of Alternatives

It may be useful to compare each alternative's positive and negative impacts to each of the criteria in tabular form, keeping in mind the law's mandate to "preserve wilderness character." Rate each alternative on a scale of +3 to -3 with +3 being 'high positive impact' and -3 being 'high negative impact' and 0 being 'no impact' or 'undeterminable.'

This table is used for comparison purposes only. It serves to provide a summary of the effects of the alternatives when looking at the combined actions and how these actions would effect the different qualities of wilderness character. A more detailed description of the effects of the alternatives to each quality of wilderness character is found in the previous section.

-3	**-2**	**-1**	**0**	**1**	**2**	**3**
High Negative Impact	Moderate Negative Impact	Low Negative Impact	No Impact/ Undeterminable	Low Positive Impact	Moderate Positive Impact	High Positive Impact

WILDERNESS CHARACTER	short-term **Alternative 1**	long-term **Alternative 1**	short-term **Alternative 2**	long-term **Alternative 2**	short-term **Alternative 3**	long-term **Alternative 3**	short-term **Alternative 4**	long-term **Alternative 4**
Untrammeled								
Physical Methods	-2	0	-2	-2	-2	-2	0	0
Piscicide Use	0	0	-3	-3	0	0	-3	-3
Translocations	-1	0	-1	-1	-1	-1	-1	-1
Stream Barriers	0	0	-1	0	-3	-3	-1	0
Undeveloped								
Installations	-1	0	-1	-1	-1	-1	0	0
Helicopter Use	-2	0	-2	-2	-2	-2	-2	-2
Natural								
Effects on Native Species	+1	-3	-3	+/-3	-2	+/-2	-3	+/-3
Ability to Accomplish Restoration of Native Ecosystem	0	-3	+3	+3	+1	+1	+3	+3

Solitude or Primitive and Unconfined Recreation								
Effects on Solitude	0	0	-1	-1	0	0	-1	-1
Effects on Primitive and Unconfined Recreation – Fishing Opps.	0	0	-1	-1	-1	-1	-1	-1
Effects on Primitive and Unconfined Recreation – Area Closures	0	0	-1	0	0	0	-1	0
Effects on Primitive and Unconfined Recreation – Restoring Opps. to view Native Ecosystems	-1	-2	+1	+3	+1	+2	+1	+3
Other Features of Value	0	0	0	0	0	0	0	0
TOTAL	**-6**	**-8**	**-12**	**-5**	**-10**	**-7**	**-9**	**-3**

SAFETY	short-term Alternative 1	long-term Alternative 1	short-term Alternative 2	long-term Alternative 2	short-term Alternative 3	long-term Alternative 3	short-term Alternative 4	long-term Alternative 4	short-term Alternative 5	long-term Alternative 5
N/A										

Safety Criterion
Occasionally, safety concerns can dictate choosing one alternative which degrades wilderness character (or other criteria) more than an otherwise preferable alternative. In that case, describe the positive and negative impacts in terms of risks to the public and workers for each alternative, but avoid pre-selecting an alternative based on the safety criteria in this section.

Documentation of Safety Concerns
To support the evaluation of alternatives, provide an analysis, reference, or documentation and avoid assumptions about risks and the potential for accidents. This documentation can take the form of agency accident-rate data tracking occurrences and severity; a project-specific job hazard analysis; research literature; or other specific agency guidelines.

The current program (Alternative A) uses a helicopter to transport heavy, fragile, or large equipment that cannot be safely carried by stock and/or crew members. This has proven to be necessary to support the operations as otherwise, crew members would have to carry heavy equipment over rough primarily trail-less terrain from the stock drop-off points. In addition, alternatives that propose the use of piscicides would involve carrying liquid materials in large (30 to 55 gallon) containers – which pose additional risks and cannot be safely carried by crew members as they are heavy and awkward – consider carrying a 30 gallon jug across rough uneven terrain and rocky areas.

For these reasons, the alternatives that propose the transport of equipment and materials to project sites utilizing only stock and crew members have not been analyzed.

OTHER CRITERIA SUMMARY	short-term Alternative A	long-term Alternative A	short-term Alternative B	long-term Alternative B	short-term Alternative C	long-term Alternative C	short-term No Action	long-term No Action
N/A								
TOTAL								

Step 2 Decision: What is the Minimum Activity?

Usually the alternative that results in the least overall adverse effect to the wilderness character will be the preferred alternative. However, there may be other considerations. If you do not select the alternative with the least overall adverse effect, provide the rationale below. Note: When selecting the preferred alternative the potential disruption of wilderness character and resources will be considered before, and given significantly more weight than, economic efficiency and convenience. If a compromise of wilderness character or resources is unavoidable, only those actions that preserve wilderness character and/or have localized, short-term acceptable adverse impacts will be allowed.

Selected Alternative: Alternative 2 – Using both Physical and Piscicides for Restoration of High Elevation Aquatic Ecosystems

Rationale for selecting this alternative (including safety criterion, if appropriate):

The no action alternative, though it has the least effect on wilderness character, has not been selected as it would not accomplish high elevation ecosystem restoration because of its limited scale and scope, and could lead to impairment of park resources if MYLF go extinct.

The three action alternatives all have varying degrees of adverse effects on wilderness character. All result in long-term adverse effects to wilderness character from extensive trammeling. All result in short and long-term effects on the undeveloped quality of wilderness character from the use of mechanized equipment and from installations such as gill nets, fish traps, and crew camps. All affect the natural quality to varying degrees, with piscicide use having the highest short and long-term adverse effects from treatment actions, but accomplishing restoration in a shorter period of time than the physical methods, thus reducing the trammeling actions overall.

Even though alternative 4, using solely piscicide to remove nonnative fish, was determined to be the least impacting on wilderness character, and would result faster results (a shorter time period to complete the projects, thus reduced trammeling actions than physical removals), the adverse effects on the natural quality of wilderness from the effects on non-target species makes this alternative less appealing than Alternative 2. Past work has shown that piscicides are not needed in all locations and physical treatment can accomplish restoration, albeit in a longer time period (6-10 years per site using physical methods v. 1-2 years per site using piscicides), resulting in all project work being completed in 15-20 years rather than the 25-35 years needed using a combination of piscicide and physical methods.

Alternative 3, using solely physical methods, would not allow for the treatment of larger, deeper, and more complex systems, while alternative 2, using a combination of physical treatment and piscicides, would allow for the work to be accomplished in larger, deeper, and more complex systems, which is vital for the long-term survival of MYLF in changing climatic conditions.

Alternative 3 is also less appealing because it would include blasting stream barriers, which would be a permanent trammel and development in wilderness.

The long-term disruption of wilderness character (up to 35 years) to accomplish restoration efforts in high elevation ecosystems is needed at this time. MYLF are facing extinction. Nonnative trout have been shown to be the major cause of their decline, with chytrid fungus outbreaks exponentially increasing their potential for demise. With the numerous mandates previously stated for the conservation and preservation of native species, and the mandate to protect the natural quality of wilderness character, the long-term trammeling actions are justified because of the long-term ecosystem-wide benefits that would result (thus improving the natural quality of wilderness character in the long-term) from implementing this alternative outweigh the disruption to wilderness character.

Therefore, in consideration of the above information, Alternative 2 is considered the proposed preferred alternative.

Cumulative Effects:

Do you know of any other projects in the vicinity of your project location(s) (past, present, or future) that have the potential to impact wilderness character?

Yes: ☒ **No:** ☐

If yes, please describe.

Resource management, research and monitoring activities occur in the parks' wilderness areas. Examples of ongoing and future planned activities include wildlife monitoring, lake sampling, air quality monitoring, exotic plant removal, resource rehabilitation and revegetation, and snow surveys. Each activity is evaluated on a case-by-case basis through the minimum requirement analysis process. When external research projects are proposed, the proposed activity is evaluated through the NPS research permitting process which also requires a minimum requirement analysis. Equipment and tools used for these projects are chosen based on the minimum requirement / minimum tool analysis, and could include non-motorized and motorized tools.

Restoration actions and studies for the conservation of native species in high elevation ecosystems of the southern Sierra Nevada have taken place in recent decades, including but not limited to MYLFs, Little Kern golden trout, California golden trout, Kern River rainbow trout and Sierra Nevada bighorn sheep. Actions include nonnative fish eradication, intensive field studies, population monitoring, reestablishment of populations in historic habitat, establishment of populations in isolated habitat, and creation or current development of a recovery plan, conservation assessment and/or conservation strategy.

There are more than 800 miles (1,287 km) of trails located within designated or potential/proposed wilderness of the parks. There are approximately 15 trail bridges in wilderness within Kings Canyon and 22 trail bridges in Sequoia. Approximately 85% of the parks' trails receive some level of maintenance each year, when conditions allow. In the high elevations, most trail work occurs during the summer. Wilderness trail maintenance activities include: maintaining, repairing, and rebuilding damaged/deteriorated walls, trail tread, drainage structures, signs, and other structural elements; rebuilding and repairing trail bridges including decking, railings, approaches, abutments, and stringers; removing or blasting fallen trees and rocks and debris from the trail corridor; repairing sections where erosion and other landscape processes have compromised trail integrity; creating barriers to discourage trail shortcutting, trail widening, and use of social trails; and, restoring landscape damage from abandoned trail segments. Maintenance crews may also mitigate hazard trees in designated camp areas. Trail crews frequently use stock (horse and mule) support for delivering supplies and equipment. On occasion, when determined the minimum tool, helicopters are used to support trail maintenance activities. At any given time there could be up to ten trail crews within the wilderness, ranging from 1 to 3 crew members up to 20 crew members, during summer months.

Helicopter flights may be used for law enforcement, SAR operations and fire suppression activities. In addition, selective helicopter flights may be determined to meet the minimum requirements for administering the area as wilderness, and to be the minimum tool for selected project work within SEKI. The types of projects where helicopter use has been considered the minimum tool include snow surveys, trail maintenance (delivery of equipment, materials and supplies), restoration/rehabilitation activities, exotic plant removal, wildlife surveys, scientific investigations, mobilizing/demobilizing wilderness ranger stations and radio repeater maintenance. As the projects are analyzed on a case-by-case basis, helicopter operations vary by project and by year. Flights can occur at any time in the year, but they are generally scheduled to minimize conflicts with wilderness users.

Provide information on Wilderness Act Section 4(c) uses proposed in this alternative:

4(c) Prohibition	Frequency and/or Quantity	Duration
mechanical transport	There could be up to three flights per restoration site per year to mobilize and demobilize the project equipment. There could be up to six flights per treatment area for the translocation of frogs. Flights would occur at mobilization to deliver supplies, and at demobilization to remove supplies and materials from the project site.	Several hours per flight.

motorized equipment	Motorized pumps would be used periodically at piscicide treatment sites for approximately 5 to 8 hours per day for 1 to 2 days per site.	
motor vehicles	N/A	N/A
motorboats	N/A	N/A
landing of aircraft	There would be up 3-6 landings at each restoration site per year and 3-6 landings per year for frog translocations.	Short-term to load and off load supplies and equipment.
structure(s)/installation(s)	Each restoration crew camp site would have 1 to 2 food/equipment storage lockers (3 to 6 would be in the wilderness at any one time) Number and location of nets and fish traps will be reported at the end of each field season.	3 to 10 years per site depending on success of treatments
temporary road	N/A	N/A

Additional mitigation, monitoring and reporting requirements ***(Reviewers provide input)*****:**

Follow-Up Form Required: Yes: ☒ **No:** ☐

Mitigation was included above. A yearly report will be completed and provided to the Wilderness Office that includes a detailed list of all 4(c) prohibited actions, including flight times/flight lines, landing locations and durations, number of food storage/equipment lockers and locations, number and locations of nets and fish traps, etc.

Prepared by:

Danny Boiano Name	Aquatic Ecologist Position	4/4/2013 Date

Review and Comments

Name/Position	Comments	Date
Wilderness Coordinator	Reviewed and commented. A. Steiner G. Fauth	5/2/2013 6/3/2013
Environmental Protection Specialist	Reviewed and updated. N. Hendricks	4/18/2013
Other reviewer as appropriate		

Approvals	Print Name	Signature	Date
Recommended:	Division Chief		
Approved:	Superintendent:		

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References and Literature Cited

LAWS USED/REFERENCED:

California Endangered Species Act. California Fish and Game Code, Sections 2050 et seq.

California Environmental Quality Act. California Public Resources Code, Section 21000 et seq.

California Wilderness Act of 1984. 16 U.S.C. 1131 et seq.; Pub. L. 98-425; 98 Stat. L. 1619. Enacted September 28, 1984.

Clean Water Act of 1972, as amended. 33 U.S.C. 1251 et seq.; Pub. L. 92-500; 86 Stat. L. 816. October 18, 1972.

Council on Environmental Quality (CEQ). 40 CFR 1500 et seq.

Endangered Species Act of 1973 (ESA), as amended. 16 U.S.C. 1531–1544; Pub. L. 93-205; 87 Stat. L. 884. Approved December 28, 1973.

Federal Insecticide, Fungicide, and Rodenticide Act of 1972. 7 USC 136-136y; PL 92-516.

General Authorities Act. 16 U.S.C. 1a-8; Pub. L. 91-383; 84 Stat. L. 825. August 18, 1970.

National Environmental Policy Act of 1969 (NEPA), as amended. 42 U.S.C. 4321 et seq.; Pub. L. 91-190, Sec. 2; 83 Stat. L. 852. Jan. 1, 1970.

National Park Service Organic Act. 16 U.S.C. 1 et seq. August. 25, 1916.

104 Stat. L. 3048. November 16, 1990.

Omnibus Public Land Management Act of 2009. H.R. 146. March 30, 2009.

Redwood Act. 16 U.S.C. 1a-1; Pub. L. 95-250; 92 Stat. L. 163. March 27, 1978.

Rehabilitation Act of 1973, as amended, section 504. 29 U.S.C. 794; Pub. L. 93-112.

Wilderness Act of 1964. 16 U.S.C. 1131–1136; P.L. 88-577; 78 Stat. L. 890. Enacted September 3, 1964.

LITERATURE CITED:

Almquist, E. 1959. Observations on the effect of rotenone emulsives on fish food organisms. Institute of Freshwater Research 40:146-160.

Anderson, R. S. 1970. Effects of rotenone on zooplankton communities and a study of their recovery patterns in two mountain lakes in Alberta. Journal Fisheries Research Board of Canada 27:1335-1356.

Bahls, P. 1992. The status of fish populations and management of high mountain lakes in the western United States. Northwest Science 66:183-193.

Beal, D. L. and R. V. Anderson. 1993. Response of zooplankton to rotenone in a small pond. Bulletin Environmental Contaminants and Toxicology 51:551-556.

Billman, H. G., C. G. Kruse, S. St-Hilaire, T. M. Koel, J. L. Arnold, and C. R. Peterson. 2012. Effects of Rotenone on Columbia spotted frogs *Rana luteiventris* during field applications in lentic habitats of southwestern Montana. North American Journal of Fisheries Management 32:781-789.

Binns, N. A. 1967. Effects of rotenone treatment on the fauna of the Green River, Wyoming. Fisheries Research Bulletin 1. Wyoming Fish and Game Commission, Cheyenne. 114pp.

Bradbury, A. 1986. Rotenone and trout stocking. Washington Department of Game, fisheries management division in Hinson, D. 2000. Rotenone Characterization and Toxicity in Aquatic Systems. University of Idaho. 13p.

Bradford, D. F. 1989. Allotopic distribution of native frogs and introduced fishes in high Sierra Nevada lakes of California: implication of the negative effect of fish introductions. Copeia 1989:775-778

Bradford, D. F. 1991. Mass mortality and extinction in a high-elevation population of *Rana muscosa*. Journal of Herpetology 25:174-177.

Bradford, D. F., and M. S. Gordon. 1992. Aquatic amphibians of the Sierra Nevada: current status and potential effects of acidic deposition on populations. Final Report, California Air Resources Board, Contract No. A1323-192, Sacramento.

Bradford, D. F., C. Swanson, and M. S. Gordon. 1992. Effects of low pH and aluminum on two species of declining amphibians in the Sierra Nevada, California. Journal of Herpetology 26:369-377.

Bradford, D. F., F. Tabatabai, and D. M. Graber. 1993. Isolation of remaining populations of the native frog, *Rana muscosa*, by introduced fishes in Sequoia and Kings Canyon National Parks, California. Conservation Biology 7:882-888.

Bradford, D. F., M. S. Gordon, D. F. Johnson, R. D. Andrews, and W. B. Jennings. 1994A. Acidic deposition as an unlikely cause for amphibian population declines in the Sierra Nevada, California. Biological Conservation 69:155-161.

Bradford, D. F., D. M. Graber, and F. Tabatabai. 1994B. Population declines of the native frog, *Rana muscosa*, in Sequoia and Kings Canyon National Parks, California. Southwestern Naturalist 39:323-327.

Bradford, D. F., S. D. Cooper, T. M. Jenkins, K. Kratz, O. Sarnelle, and A. D. Brown. 1998. Influences of natural acidity and introduced fish on faunal assemblages in California alpine lakes. Canadian Journal of Fisheries and Aquatic Sciences 55(11):2478-2491.

Brown, C. J. D., and R. C. Ball. 1943. An experiment in the use of derris root (rote-none) on the fish and fish-food organisms of third sister lake. Transactions of the American Fisheries Society 72:267-284.

Brown, C., M. Hayes, G. A. Green, and D. Macfarlane. In preparation. Sierra Nevada Mountain Yellow-legged Frog Conservation Assessment. USDA Forest Service, National Park Service, California Department of Fish and Game, U.S. Environmental Protection Agency, Natural Resource Conservation Service, U.S. Fish and Wildlife Service.

California Department of Fish and Wildlife and U.S. Forest Service. 2007. Lake Davis Pike Eradication Project Final EIR/EIS. State of California, The Resources Agency, Department of Fish and Game; United States Department of Agriculture, Forest Service Pacific Southwest Region, Plumas National Forest. http://www.dfg.ca.gov/lakedavis/EIR-EIS/

California Fish and Game Commission. 2012. Fish and Game Commission: notice of findings. Southern mountain yellow-legged frog (*Rana muscosa*), Sierra Nevada mountain-yellow legged frog (*Rana sierrae*). Sonke Mastrup, Executive Director. 14 February 2012.

Chandler, J. H., Jr., and L. L. Marking. 1982. Toxicity of Rotenone to Selected Aquatic Invertebrates and Frog Larvae. Progressive Fish Culture 4:78-80.

Cook, S. F., Jr., and R. L. Moore. 1969. The effects of a rotenone treatment on the insect fauna of a California Stream. Transactions American Fisheries Society 98:539-544.

Cowx, I. G. and P. Lamarque (eds.). 1990. Fishing with electricity: applications in freshwater fisheries management. John Wiley and Sons, Oxford, United Kingdom. 272 pp.

Cushing, C.E. Jr., Olive, J.R. 1957. Effect of toxaphene and rotenone upon the macroscopic bottom fauna of two northern Colorado reservoirs. Transactions of the American Fisheries Society 86(1):294-301.

Cutkomp, L. K. 1943. Toxicity of rotenone and derris extract administered orally to birds. Journal of Pharmacology and Experimental Therapeutics 77:238-246.

Darby, N. W., T. B. Williams, G. M. Baker, and M. Vinson. 2004. Minimizing effects of piscicides on macroinvertebrates. Wild Trout VIII Symposium, Working Together to Ensure the Future of Wild Trout, September 2004. 8 pp.

Davidson, C., H. B. Shafer, and M. R. Jennings. 2002. Spatial tests of the pesticide drift, habitat destruction, UV-B, and climate-change hypotheses for California amphibian declines. Conservation Biology 16:1588-l601.

Demong, L. 2001. The use of rotenone to re-store native brook trout in the Adirondack Mountains of New York: an overview. pp. 29-35 *in* Cailteux, R. L., L. Demong, B. J. Finlayson, W. Horton, W. McClay, R. A. Schnick, and C. Thompson, eds. Rotenone in fisheries: are the rewards worth the risks? American Fisheries Society, Trends in Fisheries Science and Management 1, Bethesda, Maryland.

Drost, C., and G. M. Fellers. 1996. Collapse of a regional frog fauna in the Yosemite area of the California Sierra Nevada, USA. Conservation Biology 10:414-425.

Dudgeon, D. 1990. Benthic community structure and the effect of rotenone piscicide on invertebrate drift and standing stocks on two Papau New Guinea streams. Archives Hydrobiologie 199:35-53.

Engstrom-Heg, R., R. T. Colesante, and E. Silco. 1978. Rotenone tolerances of stream-bottom insects. New York Fish and Game Journal 25:31-41.

Environmental Protection Agency. 2007A. Reregistration eligibility decision for rotenone. Office of Prevention, Pesticides, and Toxic Substances. EPA 738-R-07-005.

Farringer, J. E. 1972. The determination of the acute toxicity of rotenone and Bayer 73 to selected aquatic organisms. University of Wisconsin, Madison, Wisconsin. Master's Thesis. May 1972.

Finlay, J. C. and V. T. Vredenburg. 2007. Introduced trout sever trophic connections in watersheds: consequences for a declining amphibian. Ecology 88: 2187-2198.

Finlayson, B. J., R. A. Schnick, R. L. Cailteux, L. Demong, W.D. Horton, W. McClay, C. W. Thompson, and G. J. Tichacek. 2000. Rotenone use in fisheries management: administrative and technical guidelines manual. American Fisheries Society, Bethesda, Maryland.

Finlayson, B., W. L. Somer, and M. R. Vinson. 2010. Rotenone toxicity to rainbow trout and several mountain stream insects. North American Journal of Fisheries Management 30:102-111.

Fish and Wildlife Service, U.S. Department of the Interior. 2003. Endangered and threatened wildlife and plants: 12-month finding for a petition to list the Sierra Nevada distinct population segment of the mountain yellow-legged frog (*Rana muscosa*). Federal Register 68:2283-2303.

Fish and Wildlife Service, U.S. Department of the Interior. 2007A. Endangered and threatened wildlife and plants: 12-month finding on a petition to list the Sierra Nevada distinct population segment of the mountain yellow-legged frog (*Rana muscosa*). Federal Register 72:34657-34661.

Fish and Wildlife Service, U.S. Department of the Interior. 2007B. Recovery Plan for the Sierra Nevada Bighorn Sheep. Sacramento, California.

Fish and Wildlife Service, U.S. Department of the Interior (and California Department of Fish and Game). 2010. Paiute cutthroat trout restoration project: Silver King creek, Humboldt-Toiyabe National Forest, Alpine County, California. Final EIS and EIR. http://www.fws.gov/nevada/highlights/comment/pct/index.htm.

Fish and Wildlife Service, U.S. Department of the Interior. 2013. Endangered and threatened wildlife and plants; Endangered status for the Sierra Nevada yellow-legged frog and the northern district population segment of the mountain yellow-legged frog, and threatened status for the Yosemite toad. Federal Register 78:24472-24514. A complete list of references cited in the rulemaking is available on the Internet at http://www.regulations.gov and upon request from the Sacramento Fish and Wildlife Office.

Fontenot, L. W., G. P. Noblet, and S. G. Platt. 1994. Rotenone hazards to amphibians and reptiles. Herpetological Review 25:150-156.

Grinnell, J., and T. I. Storer. 1924. Animal life in the Yosemite. University of California Press, Berkeley.

Hamilton, B. T., S. E. Moore, T. B. Williams, N. Darby, and M. Vinson. 2009. Comparative effects of rotenone and antimycin on macroinvertebrate diversity in two streams in Great Basin National Park, Nevada. North American Journal of Fisheries Management 29:1620-1635.

Hamilton, H.L. 1941. The biological action of rotenone on freshwater animals. Proceedings from Iowa Academy of Sciences. 48: 467-479.

Haque, K.A. 1971. Rotenone and its use in eradication of undesirable fish from ponds. Pakistan Journal of Scientific and Industrial Research. 14: 385-387. *in* Fontenot, L. W., G. P. Noblet, and S. G. Platt. 1994. Rotenone hazards to amphibians and reptiles. Hepetological Review 25:150-156.

Herbst, D. B., E. L. Silldorff, and S. D. Cooper. 2009. The influence of introduced trout on native aquatic invertebrate communities in a paired watershed study of streams in Yosemite National Park. Freshwater Biology 54:1324-1342.

Houf, L. J., and R. S. Campbell. 1977. Effects of antimycin A and rotenone on macrobenthos in ponds. U.S. Fish and Wildlife Service, Investigations in Fish Control No. 80. 29pp.

Idaho Department of Fish and Game (IDFG). 2010. Subproject #1: Use of tiger muskellunge to remove brook trout from high mountain lakes. Annual Performance Report. IDFG Report No. 10-06.

Jarvinen, A.W. and G.T. Ankley. 1998. Linkage of effects to tissue residues: development of a comprehensive database for aquatic organisms exposed to inorganic and organic chemicals. SETAC Technical Publications Series. Society of Environmental Toxicology and Chemistry. Pensacola, Florida. 364 pp.

Jennings, M. R., and M. P. Hayes. 1994. Amphibian and reptile species of special concern in California, Final Report. The California Department of Fish and Game, Inland Fisheries Division, Rancho Cordova, California, Contract No. 8023.

Kagarise Sherman, C. 1980. A comparison of the natural history and mating system of two anurans: Yosemite toads (*Bufo canorus*) and black toads (*Bufo exsul*). Ph.D. Dissertation, University of Michigan, Ann Arbor, Michigan. 394 pp.

Kiser, R.W., J.R. Donaldson, and P.R. Olson. 1963. The Effect of Rotenone on Zooplankton Populations in Freshwater Lakes. Transactions of the American Fisheries Society 92(1):17–24.

Knapp, R. A. 1996. Nonnative trout in natural lakes of the Sierra Nevada: an analysis of their distribution and impacts on native aquatic biota. Pp 363-407 in Sierra Nevada Ecosystem Project: final report to Congress. Volume III. Centers for Water and Wildland Resources, University of California, Davis.

Knapp, R. A., and K. R. Matthews. 1998. Eradication of nonnative fish by gill-netting from a small mountain lake in California. Restoration Ecology 6:207-213

Knapp, R. A., and K. R. Matthews. 2000. Non-native fish introductions and the decline of the mountain yellow-legged frog from within protected areas. Conservation Biology 14:428-438

Knapp, R. A., K. R. Matthews, and O. Sarnelle. 2001. Resistance and resilience of alpine lake fauna to fish introductions. Ecological Monographs 71:401–421

Knapp, R. A. 2003. Inventory of high elevation waterbodies in Sequoia and Kings Canyon National Parks. Unpublished data submitted to National Park Service, Sequoia and Kings Canyon National Parks, Three Rivers, CA.

Knapp, R. A. 2005A. Effects of nonnative fish and habitat characteristics on lentil herpetofauna in Yosemite National Park, USA. Biological Conservation 121:265-279

Knapp, R. A., C. P. Hawkins, J. Ladau, and J. G. McClory. 2005. Fauna of Yosemite National Park Lakes has low resistance but high resilience to fish introductions. Ecological Applications 15:835-847.

Knapp, R. A., D.M. Boiano, and V. T. Vredenburg. 2007. Removal of nonnative fish results in population expansion of a declining amphibian (mountain yellow-legged frog, *Rana muscosa*). Biological Conservation 135:11-20

Knapp, R. A., and O. Sarnelle. 2008. Recovery after local extinction: factors affecting re-establishment of alpine lake zooplankton. Ecological Applications 18:1850-1859.

Knapp, R. A., C. J. Briggs, T. C. Smith, and J. R. Maurer. 2011. Nowhere to hide: impact of a temperature-sensitive amphibian pathogen along an elevation gradient in the temperate zone. Ecosphere 2:art93.

Liang, C. T.-P. 2010. Habitat modeling and movements of the Yosemite toad (*Anaxyrus* (=*Bufo*) *canorus*) in the Sierra Nevada, California. Ph.D. Dissertation. University of California, Davis.

Ling, N. 2003. Rotenone a review of its toxicity and use for fisheries management. Science for Conservation 211. Department of Conservation, Wellington, New Zealand. 40 pp.

Mangum, F. A. and J. L. Madrigal. 1999. Rotenone effects on aquatic macroinvertebrates of the Strawberry River, Utah: a five year summary. Journal of Freshwater Ecology 14:125-135.

Marking, L. L. and T. D. Bills. 1976. Toxicity of Rotenone to Fish in Standardized Laboratory Tests. Investigations in Fish Control report number 72. U.S. Fish and Wildlife Service, National Fishery Research Center, La Crosse, Wisconsin.

Matthews, K. R., K. L. Pope, H. K. Preisler, and R. A. Knapp. 2001. Effects of nonnative trout on Pacific Treefrogs (*Hyla regilla*) in the Sierra Nevada. Copeia 2001:1130-1137.

Matthews, K. R., R. A. Knapp, and K. L. Pope. 2002. Garter snake distributions in high elevation aquatic ecosystems: Is there a link with declining amphibian populations and nonnative trout introductions? Journal of Herpetology 36:16-22.

Matthews, K. R., and H. K. Preisler. 2010. Site fidelity of the declining amphibian *Rana sierrae* (Sierra Nevada yellow-legged frog). Canadian Journal of Fisheries and Aquatic Sciences 67:243-255.

Melaas, C. L., K. D. Zimmer, M. G. Butler, and M. A. Hanson. 2001. Effects of rotenone on aquatic invertebrate communities in prairie wetlands. Hydrobiologia 459:177-186.

Meronek, T. G., P. M. Bouchard, E. R. Buckner, T. M. Burri, K. K. Demmerly, D. C. Hatleli, R. A. Klumb, S. H. Schmidt, and D. W. Coble. 1996. A review of fish control projects. North American Journal of Fisheries Management 16:63-74.

Morgan J. A. T., V. T. Vredenburg, L. J. Rachowicz, R. A. Knapp, and M. J. Stice. 2007. Population genetics of the frog-killing fungus *Batrachochytrium dendrobatidis*. Proceedings of the National Academy of Sciences 104:13845–13850.

Morrison, B. R. S. 1977. The effects of rotenone on the invertebrate fauna of three hill streams in Scotland. Fish Management 8:128-139.

Moyle, P. B., R. M. Yoshiyama, and R. A. Knapp. 1996. Status of fish and fisheries. Pages 953-973 *in* Sierra Nevada Ecosystem Project: final report to Congress. Volume II. Centers for Water and Wildland Resources, University of California, Davis.

National Park Service, U.S. Department of the Interior. 2001. Preliminary Restoration of Mountain Yellow-legged Frogs, Environmental Assessment. National Park Service, Sequoia and Kings Canyon National Parks, Three Rivers, California.

National Park Service, U.S. Department of the Interior. 2006A. Management Policies 2006. Washington, D. C.

National Park Service, U.S. Department of the Interior. 2007. Final General Management Plan and Comprehensive River Management Plan/Environmental Impact Statement. Sequoia and Kings Canyon National Parks, Three Rivers, California. 657 pp.

National Park Service, U.S. Department of the Interior. 2009C Director's Order #41: Wilderness Stewardship.

National Park Service, U.S. Department of the Interior. 2009D. Management Directive 49: Minimum Requirement Analysis and Determination in DEPO Wilderness.

National Park Service, U.S. Department of the Interior. 2011A. Mountain Yellow-legged Frog Restoration Project: 2010 Field Season Summary. Sequoia and Kings Canyon National Park, 47050 Generals Highway, Three Rivers, CA 93271.

National Park Service, U.S. Department of the Interior. 2012A. Mountain Yellow-legged Frog Restoration Project: 2011 Field Season Summary. Sequoia and Kings Canyon National Park, 47050 Generals Highway, Three Rivers, CA 93271.

National Park Service, U.S. Department of the Interior. Unpublished Data (2001-2012). Aquatic Resources Office. Sequoia and Kings Canyon National Park, 47050 Generals Highway, Three Rivers, CA 93271.

National Park Service, U.S. Department of the Interior. 2013. Adapting to change. Climate change response program: adaptation brief. Fort Collins, CO. 1 pg.

Neves, R. J. 1975. Zooplankton recolonization of a lake cove treated with rotenone. Transactions of the American Fisheries Society 104:390–393.

Niemi, G. J., P. DeVore, N. Detenbeck, D. Taylor, K. Lima, J. Pastor, J. D. Yount, and R. J. Naiman. 1990. Overview of case studies on recovery of aquatic systems from disturbance. Environmental Management 14:571-587.

Pope, K. L. 1999. Natural history notes: *Rana muscosa* (mountain yellow-legged frog) diet. Herpetological Review 30:163–164.

Pope, K. L., and K. R. Matthews. 2001. Movement ecology and seasonal distribution of mountain yellow-legged frogs, *Rana muscosa*, in a high-elevation Sierra Nevada basin. Copeia 2001:787-793.

Rachowicz, L. J., J. M. Hero, R. A. Alford, J. W. Taylor, J. A. T. Morgan, and V. T. Vredenburg. 2005. The novel and endemic pathogen hypotheses: competing explanations for the origin of emerging infectious diseases of wildlife. Conservation Biology 19:1441–1448.

Rachowicz, L. J., R. A. Knapp, J. A. T. Morgan, M. J. Stice, and V. T. Vredenburg. 2006. Emerging infectious disease as a proximate cause of amphibian mass mortality. Ecology 87: 1671–1683.

Reinertsen, H., A. Jensen, J. I. Koksvik, A. Langeland, and Y. Olsen. 1990. Effects of fish removal on the limnetic ecosystem of a eutrophic lake. Canadian Journal of Fisheries and Aquatic Sciences 47:166-173.

Resh, V. H. 1979. Sampling variability and life history features: basic considerations in the design of aquatic insect studies. Journal of the Fisheries Research Board of Canada 36:290-311.

Sanders, H. O. and O. B. Cope. 1968. The relative toxicities of several pesticides to naiads of three species of stoneflies. Journal of Limnology and Oceanography 13:112-117.

Schindler, D. E., R. A. Knapp, and P. R. Leavitt. 2001. Alteration of nutrient cycle and algal production resulting from fish introductions into mountain lakes. Ecosystems 4:301–321.

Singer, T. P. and R. R. Ramsay. 1994. The reaction sites of rotenone and ubiquinone with mitochondrial NADH dehydrogenase. Biochimica et Biophysica Acta 1187:198-202.

Stoddard, J. L. 1987. Microcrustacean communities of high-elevation lakes in the Sierra Nevada, California. Journal of Plankton Research 9:631-650.

Vinson, M. R., and C. P. Hawkins. 1996. Effects of sampling area and subsampling procedure on comparisons of taxa richness among streams. Journal of the North American Benthological Society 15:392-399.

Vinson, M. R. and D. K. Vinson. 2007. An analysis of the effects of rotenone on aquatic invertebrate assemblages in the Silver King Creek Basin, California. Unpublished report for U.S. Forest Service, Humboldt-Toiyabe National Forest, Carson City, NV by Moonlight Limnology. 270 pp.

Vinson, M. R., E. C. Dinger, and D. K. Vinson. 2010. Piscicide and invertebrates: after 70 years, does anyone really know? Fisheries 35:61-71.

Vredenburg V.T. 2004. Reversing introduced species effects: experimental removal of introduced fish leads to rapid recovery of a declining frog. Proceedings of the National Academy of Sciences 101:7646–7650.

Vredenburg, V. T., R. Bingham, R. Knapp, J. A. T. Morgan, C. Moritz, and D. Wake. 2007. Concordant molecular and phenotypic data delineate new taxonomy and conservation priorities for the endangered mountain yellow-legged frog. Journal of Zoology 271:361–374

Vredenburg,V. T., R. A. Knapp, T. S. Tunstall, and C. J. Briggs. 2010. Dynamics of an emerging disease drive large-scale amphibian population extinctions. Proceedings of the National Academy of Sciences 107:9689–9694.

Whelan, J. E. 2002. Aquatic macroinvertebrate monitoring results of the 1995 and 1996 rotenone treatments of Manning Creek, Utah. Utah Division of Natural Resources publication number 02-04. 38 pp.