U.S. Department of the Interior
National Park Service

Sequoia and Kings Canyon National Parks
California

Restoration of Native Species in High Elevation Aquatic Ecosystems Plan and Final Environmental Impact Statement

Volume 1 • Chapters 1 – 5
Glossary, References

June 2016

United States Department of the Interior

NATIONAL PARK SERVICE
Sequoia and Kings Canyon National Parks
47050 Generals Highway
Three Rivers, California 93271-9651
(559) 565-3341

IN REPLY REFER TO:

1.A.1

June 7, 2016

Dear Friends of Sequoia and Kings Canyon National Parks:

I am pleased to announce the completion of the High Elevation Aquatic Ecosystem Restoration Plan and Final Environmental Impact Statement (Restoration Plan/FEIS). This Restoration Plan/FEIS will guide our management actions to restore and conserve native species diversity and ecological function to selected high elevation aquatic ecosystems that have been adversely impacted by human activities, particularly the past stocking of nonnative trout. The project would also increase the resistance and resilience of native species and ecosystems to human-induced environmental modifications such as disease and unprecedented climate change.

Over the past 16 years, we have effectively eradicated nonnative trout in 15 lakes and ponds using gill nets and electrofishers. Nonnative fish are currently being removed from eleven additional lakes and ponds. The removal of nonnative trout has been shown to be beneficial for native species. However, we have not had the tools necessary to restore habitats on a larger scale. If approved, this Restoration Plan/FEIS would allow us to use additional tools, including piscicides, for conducting high elevation aquatic ecosystem restoration at the landscape scale in the parks.

This Restoration Plan/FEIS would help us restore up to 15% of our high elevation lakes and streams over the next 25 to 35 years. Its implementation would affect up to 85 of the 550 nonnative fish-containing lakes, ponds, and marshes, and approximately 31 miles of streams in these parks, thus, the impact to recreational fishing would be minor.

The Restoration Plan/FEIS is available on the NPS Planning, Environment, and Public Comment (PEPC) website at http://parkplanning.nps.gov/aquatics. A limited number of printed documents are available. To request a printed document or CD, call (559) 565-3102, or write to me at the above address.

A 30-day "no-action" period will begin on the date the Environmental Protection Agency publishes the notice of availability of the final plan in the *Federal Register*, which is scheduled to occur on June 10, 2016, after which the NPS will prepare a record of decision (ROD). After approval of the ROD by the Pacific West Regional Director, the selected plan will be announced through local and regional press, and posted on the PEPC website. The expansion of the program, if approved, would start later this summer, however treatments using piscicide would not begin until 2017 or 2018.

Sincerely,

Woody Smeck

Woody Smeck
Superintendent

Final Restoration of Native Species in High Elevation Aquatic Ecosystems Plan
Environmental Impact Statement

Sequoia and Kings Canyon National Parks

Lead Agency: National Park Service
U.S. Department of the Interior / National Park Service

ABSTRACT

The purpose of the Restoration of Native Species in High Elevation Aquatic Ecosystems Plan and Final Environmental Impact Statement (Restoration Plan/FEIS) is to restore and conserve high elevation aquatic ecosystems within Sequoia and Kings Canyon National Parks (SEKI or parks). The Restoration Plan/FEIS establishes the long-term management direction to restore and conserve SEKI's high elevation aquatic species and ecosystems.

The Restoration Plan/FEIS presents and analyzes one no-action alternative and three action alternatives that provide alternative methods for restoring high elevation habitats that are important for the conservation of native species, ecosystems and processes, and for mitigating the potential effects from climate change. The NPS is considering the use of physical methods, such as gill nets and electrofishers, and the use of piscicides (rotenone) in order to eradicate nonnative fish from these ecologically significant habitats. Additionally, this Restoration Plan/FEIS proposes to conduct a suite of active restoration methods to recover two species of federally endangered frogs that occur in SEKI and have been severely impacted by nonnative fish and disease.

The draft Restoration Plan and Draft EIS was available to the public, federal, state, and local agencies, tribes, and organizations for a 60-day public review period from September 26, 2013 to November 25, 2013. In October 2013, due to an extended shutdown of the federal government, and the unavailability of federal systems that allowed the review of the draft plan, the public review period was extended to December 17, 2013. The NPS received 123 public comment letters from individuals, interest groups, businesses, or government agencies. Substantive comments are addressed in appendix E of this Restoration Plan/FEIS, and the text has been changed, clarified, or expanded where necessary. A summary of the changes is included in Chapter 1.

The final Restoration Plan/FEIS is available on the NPS Planning, Environment, and Public Comment (PEPC) website at http://parkplanning.nps.gov/aquatics. A limited number of printed documents are available. To request printed documents or CDs, call (559) 565-3102, or write to the below address. A 30-day "no-action" period will begin on the date the Environmental Protection Agency publishes the notice of availability of the final plan in the Federal Register, after which the NPS will prepare a record of decision (ROD). After approval of the ROD by the Pacific West Regional Director, the selected alternative will be announced through local and regional press, and on the PEPC website.

Superintendent
Attn: *Restoration Plan/Final EIS*
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(559)-565-3101

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EXECUTIVE SUMMARY

This *Restoration of Native Species in High Elevation Aquatic Ecosystems Plan / Final Environmental Impact Statement* (Restoration Plan/FEIS) analyzes a range of management alternatives for the restoration and conservation of high elevation aquatic ecosystems within Sequoia and Kings Canyon National Parks (SEKI or parks), California. This Restoration Plan/FEIS analyzes the impacts that could result from no action, or implementation of any of three action alternatives.

Readers may gain a quick summary of the proposed action by reviewing, at a minimum, the following parts of this document:

- This Executive Summary
- The Table of Contents (for specific sections of interest)
- “Elements Common to All Alternatives” and “Alternative B: Prescription Treatment (Physical and Piscicide) Preceding Restoration (NPS Preferred Alternative)”
- Appendices that provide maps (appendix B), in-depth background information (appendices C, G, H, and J), and site assement and protocol information (appendices I and N)

In addition, the glossary may help with unfamiliar terms.

The National Park Service (NPS) is considering expanding the current high elevation aquatic ecosystem restoration program within SEKI to encompass additional sites and incorporate alternative methods. Thus far, SEKI has restored 15 lakes and ponds and has nearly finished restoring 10 lakes and ponds by eradicating nonnative fish using physical tools (e.g., gill nets and electrofishers). Although fish eradication is feasible, and beneficial for native species (Vredenburg 2004, Knapp et al. 2007, NPS 2012A), eradication using physical tools is only feasible in relatively simple (non-complex) habitat: generally lakes with few and/or small connected stream sections. Some of the remaining potential restoration areas in SEKI that have value for addressing ecosystem recovery (including whole basins) contain much more complex habitat involving large lakes or clusters of many lakes with many and/or large connected streams. Many of these areas also contain large, deep and/or cold lakes that have the best capacity to resist drier and warmer conditions expected in the future due to global climate change. Restoring larger areas is thus critical for native species to continue to have access to high-quality habitat once smaller waterbodies dry up or become too warm.

To broaden the types of lakes that can be restored (including whole basins), the NPS is proposing to expand the current program, both in the number of waterbodies to be restored and the types of treatment methods to be used. The plan evaluates expanding restoration efforts to more complex aquatic ecosystems using both physical-based and alternative methods. The NPS is considering using piscicides (rotenone) in order to restore these ecologically significant habitats.

A piscicide is a substance that is toxic to fish and whose intended function is to eliminate undesirable fish from a waterbody. Two piscicides have been widely used by fishery managers to eliminate trout species - rotenone (derived from plants) and antimycin A (derived from bacteria). However, the CFT Legumine™ formulation of rotenone is currently the only piscicide registered for use in California. Therefore, the CFT Legumine™ formulation of rotenone is the only proposed piscicide treatment evaluated in this plan.

Additionally, this Restoration Plan/FEIS proposes to conduct a suite of active restoration methods to recover two species of federally endangered frogs that occur in SEKI and have been severely impacted by nonnative fish and disease. Most of the remaining frog populations are small, fragmented from each other, still adapting to living with disease, and vulnerable to extirpation. Direct actions that increase the number and size of populations, in addition to habitat restoration via fish eradication, are needed to help prevent these species from experiencing further declines, to remove the threat of extirpation, and to eventually recover them on the parks scale. The restoration actions in this plan are aligned with an interagency frog conservation strategy that identifies recovery actions for these species.

Project Site Location

SEKI protects 865,964 acres [ac; 350,443 hectares (ha)] along the western slope of the Sierra Nevada mountain range in east-central California (Figure 1). Sequoia National Park, established in 1890, and Kings Canyon National Park, established in 1940, are administered as a single unit that rises from the low western foothills at 1,370 feet [ft; 418 meters (m)] to the summit of Mount Whitney at approximately 14,494 ft (4,418 m). These two parks make up the geographical area for this Restoration Plan/FEIS. Two wilderness areas are located within SEKI, including the Sequoia-Kings Canyon Wilderness and John Krebs Wilderness. The entirety of SEKI is within Tulare and Fresno counties. Drivable access is by California State Routes 180 and 198, which within SEKI is known as the Generals Highway.

In SEKI, native fish species were found in the lower elevation reaches of the Kaweah, Kern, and Kings Rivers, typically below 6,000 ft (1,800 m) in elevation (Moyle et al. 1996). The high elevation aquatic ecosystems addressed in this Restoration Plan/FEIS include selected lakes, ponds, streams, and marshes found from approximately 6,000 ft (1,800 m) to 12,000 ft (3,700 m) in elevation, with the majority of sites found above 10,000 ft (3,000 m). All of the proposed restoration sites, and virtually all waters in the high elevation lake basins, which are perched above the high gradient streams, were naturally fishless. In these areas, SEKI contains approximately 3,500 high elevation lakes, ponds, and marshes (waterbodies) (Knapp R., unpublished data), and more than 1,000 miles [mi; 1,600 kilometers (km)] of rivers and streams (NPS 2005), including portions of the headwaters of the Kaweah, Kern, Kings, San Joaquin, and Tule Rivers. The majority of the 3,500 waterbodies–approximately 2,500 are ponds (< 2.5 ac/1 ha), many of which are very small, only holding snowmelt water during early summer and drying completely during late summer (~1,000 are < 0.25 ac/0.1 ha). Approximately 1,000 of the 3,500 waterbodies are lakes (2.5 ac/1 ha or larger), all of which currently hold water year-round. In addition, approximately 600 of the 1,000 lakes are 5 ac (2 ha) or larger, which will buffer them from the drying conditions expected with climate change.

These waterbodies occur in historically fishless lake basins and provide habitat for a diverse assemblage of native species that developed over thousands of years in a fishless environment (Moyle et al. 1996). From 1870 to 1988, one or more species of nonnative trout, including golden, rainbow, golden x rainbow hybrid, brook, and brown trout, were introduced into many heretofore fishless waterbodies throughout SEKI (Christenson 1977, Knapp 1996). Surveys conducted from 1997 to 2002 determined that self-sustaining nonnative trout populations had become established in 575 lakes, ponds, and marshes (Knapp R., unpublished data), plus connecting streams, and nearly all streams that drain these sites from high to low elevations.

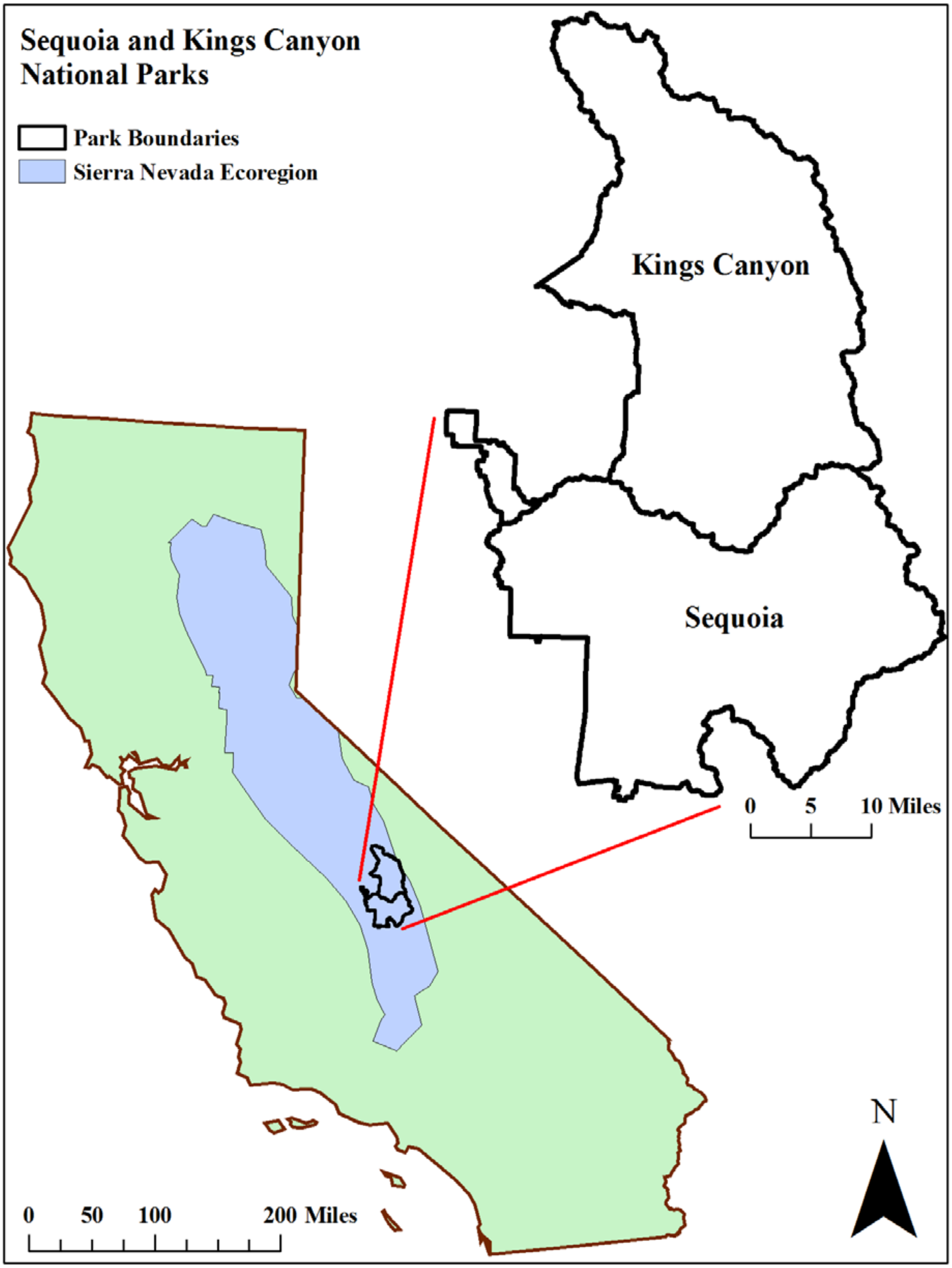

Figure 1. Regional map of Sequoia and Kings Canyon National Parks

Purpose of the Plan

The purpose of this Restoration Plan/FEIS is to guide management actions by the NPS to restore and conserve the native species diversity and ecological function of selected high elevation aquatic ecosystems that have been adversely impacted by human activities including the introduction of nonnative fish, and to increase the resistance and resilience of native species and ecosystems to human-induced environmental modifications such as disease and unprecedented climate change. The management strategies included in this Restoration Plan/FEIS are intended to be adaptive and dynamic, allowing for the incorporation of new scientific information over time to best meet the objectives of the aquatic ecosystem restoration program. Therefore, this plan calls for monitoring, assessment, and regular programmatic reviews. During implementation, the effectiveness of this plan would be reviewed at least once every 5 to 10 years to evaluate new species information, scientific findings, habitat information, and restoration and monitoring results. Following each review, the plan would be revised if necessary to address emerging issues and incorporate new information into the management strategies. Additional public involvement would occur as appropriate.

The overall goal of this Restoration Plan/FEIS is to restore clusters of waterbodies to their naturally fishless state in strategic locations across SEKI to create high elevation ecosystems having more favorable habitat conditions for the persistence of native species and ecosystem processes. The Restoration Plan/FEIS presents a range of alternative management actions to restore and conserve native species diversity and ecological function to selected high elevation aquatic ecosystems in SEKI that have been disturbed by human activities, particularly the stocking of nonnative trout. The Restoration Plan/FEIS describes the no action alternative and three action alternatives that are being considered during this planning effort, and presents an analysis of the impacts of the alternatives on the natural, cultural, and physical resources in SEKI. The alternatives represent a range of reasonable and feasible options for addressing the goals and objectives of this plan and the issues and concerns raised by parks staff, other government agencies, and members of the public during the plan's scoping process. Upon conclusion of this Restoration Plan/FEIS, one of the four alternatives would become the *Restoration of Native Species in High Elevation Aquatic Ecosystems Plan*.

Need for the Action

This Restoration Plan/FEIS is needed to provide long-term management direction to restore and conserve SEKI's high elevation aquatic species and ecosystems. 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 (NPS 2006A) and is among the desired conditions established in SEKI's *Final General Management Plan/Final Environmental Impact Statement* (GMP; NPS 2007).

Action is needed at this time:

- because nonnative fish have severely reduced native biological diversity and disrupted ecological function;
- to prevent the extirpation of two species of mountain yellow-legged frogs (*Rana muscosa* and *Rana sierrae;* MYLF) in the parks, and to restore MYLF populations to many locations in the parks where they have been extirpated;
- to further the NPS's mission and policy directives to conserve native animals, plants, and processes found in SEKI's aquatic ecosystems;
- because large scale restoration of more complex habitat (areas containing large lakes or clusters of many lakes with many and/or large connecting stream sections) is critical for native species and ecosystem recovery;
- to increase the resistance and resilience of native high elevation aquatic species and ecosystems to human-induced environmental change; and
- to enhance and preserve the natural quality of wilderness character.

Many studies conducted in SEKI and elsewhere in the Sierra Nevada analyzed 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 have 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 alter, deplete, or eliminate populations of these animals from naturally fishless habitats. The animals that are consumed by nonnative trout occupy the middle of native food webs, functioning as both prey and predators. Their reductions as prey result in less food being available to native predators such as snakes, birds, and mammals, altering the distribution and abundance of these animals. Their reductions as predators affect the roles of herbivores and detritivores and associated nutrient cycling. When extirpations occur, all associated ecosystem function associated with the species is lost. 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 the parks' high elevations. The NPS has shown that eradication of nonnative trout from relatively simple habitats in SEKI can reverse these impacts on a small scale (NPS 2012A), but the parks' current restoration program does not include the tools necessary to restore habitats on larger scales. This Restoration Plan/FEIS evaluates additional tools for conducting high elevation aquatic ecosystem restoration at the landscape scale in SEKI.

Two species that are integral components of SEKI's high elevation aquatic ecosystems are the MYLFs. Nonnative trout and disease (amphibian chytrid fungus) are the primary factors that have caused formerly abundant MYLFs to disappear from more than 92% of historic sites in the Sierra Nevada (Vredenburg et al. 2007), with similarly large losses in SEKI. Most of the remaining MYLF populations are small, isolated, often restricted to small ponds vulnerable to drying, and diseased – with low survival and recruitment rates. As a result, both species were listed under the California Endangered Species Act in 2012 (CFGC 2012) and the federal Endangered Species Act in 2014 (FWS 2014A). Intervention is urgently needed to prevent the extirpation of both MYLF species from the parks.

Objectives of the Restoration Program

The following management objectives were developed for this Restoration Plan/FEIS based on the purpose and need for the plan. The objectives, which are in accordance with the executive orders, laws, policies, and plans that guide management of natural resources in national parks, are summarized below:

A) Restore and conserve the natural abundances, distributions, and functions of native species, populations, and communities within selected high elevation aquatic ecosystems, by:

- implementing management actions to create more favorable conditions for these populations to persist and be more resilient to human-induced changes to environmental conditions; and
- restoring habitat to its historically fishless condition at the parks scale, including the eradication of fish from up to 85 (15%) of 550 nonnative fish-containing lakes, ponds, and marshes, approximately 31 miles of streams, and connected fish-containing habitat as necessary.

B) Develop a long-term conservation strategy for both species of MYLFs (*R. muscosa* and *R. sierrae)* to ensure the self-sustaining, long-term viability, and evolution of MYLF populations in perpetuity within portions of their present and historic geographic range within the parks, and to maintain the genetic and ecological diversity of these species. Specific objectives related to this strategy include:

- reverse widespread loss of the ecological function formerly provided by MYLFs and maintain the viability of existing MYLF populations throughout the range of both species within the parks;
- restore selected habitat and expand existing MYLF populations;

- re-establish MYLFs in selected basins where populations were historically present, but are now absent; and
- collaborate with partner agencies and organizations to exchange information, enhance use of available resources, and strategically restore and conserve MYLFs in the Sierra Nevada.

C) Identify presently incomplete information that is needed for effective conservation and management of aquatic ecosystems in the face of unprecedented rates of human-induced change.

D) Use results from restoration efforts and new knowledge from research studies to refine program methodologies over time and mitigate impacts that have the potential to occur during restoration.

E) Restore and protect natural processes in wilderness, using an appropriate range of management actions derived from thorough analyses of potential effects to wilderness character and resources.

F) Provide an appropriate range of visitor experiences and recreational opportunities at wilderness lakes and streams concurrent with minimizing the degradations that have occurred to the biological integrity of high elevation aquatic ecosystems.

The objectives for this plan are grounded in a series of laws commonly known as the National Park Service Organic Act of 1916, the General Authorities Act of 1970, and the Redwood Amendments of 1978 that provide overall management direction for units of the National Park System. 54 U.S.C. 100101 *et. seq*. These interrelated authorities express the fundamental purpose of the National Park System, which begins with the mandate to conserve park resources and values and also includes the mandate to provide for visitor enjoyment of these resources and values. The mandate to conserve park resources and values is complemented by a statutory prohibition on the impairment of park resources and values.

Background
Historically, SEKI's high elevation waterbodies were inhabited by a diverse assemblage of aquatic species that developed over thousands of years in a fishless environment. This fishless environment was due to extensive Pleistocene glaciation that created the waterbodies and steep topography that contained many barriers to fish passage (Moyle et al. 1996). As a result, fish were naturally restricted in distribution to low or middle elevation streams, from 4,900 ft (1,500 m) to 9,800 ft (3,000 m) depending on the watershed (Moyle et al. 1996).

The first recorded stocking of nonnative trout into SEKI's fishless high elevation waterbodies occurred in 1870, and unrecorded stockings potentially occurred as early as the 1850s (Christenson 1977). Travelers used pack animals to move fish and stock the more easily accessible waters until the 1940s, and then virtually all the remaining fishless waters were stocked by aircraft until 1988, when all stocking was terminated. Although stocking no longer occurs in SEKI, nonnative trout established self-sustaining populations in approximately 575 water bodies and hundreds of miles of streams, due to an abundance of suitable habitat that fish were able to utilize once introduced.

In contrast, MYLFs were historically one of the most abundant vertebrates in high Sierra Nevada lakes and streams (Grinnell and Storer 1924). These frogs are endemic to high elevations of the Sierra Nevada and southern California and are vital species in these aquatic ecosystems, functioning as predators, abundant prey, and agents of nutrient and energy cycling (Finlay and Vredenburg 2007). By 1915, MYLFs became rare to extinct in lakes containing nonnative trout, while remaining common to abundant in most fishless lakes (Grinnell and Storer 1924).

In the 1980s and 1990s, researchers and NPS staff observed that amphibians, particularly MYLFs, appeared to be declining even in fishless habitats (Graber D., pers. comm., 2012). Several studies ensued to quantify the MYLF decline and attempted to determine its causal factors. The primary conclusions from these studies were that (1) lake acidity levels were not elevated and thus did not appear to be a contributing factor to MYLF decline (Bradford et al. 1994A), and (2) MYLFs were much less likely to occur in lakes with nonnative fish versus fishless lakes (Bradford et al. 1994B, Knapp and Matthews 2000).

Studies in the past 15 years determined that MYLF populations have disappeared from more than 92% of historic localities in the Sierra Nevada, with similarly large losses in SEKI (Vredenburg et al. 2007). Due to this steep decline, in 2003, the U.S. Fish and Wildlife Service (FWS) listed the Sierra Nevada population of MYLFs as a federal candidate species under the Endangered Species Act (FWS 2003).

Extensive research identified two primary factors for this decline. The first factor is the introduction of nonnative trout, which have several direct effects on MYLFs, including predation, competition for food, restriction of breeding to marginal habitat, and fragmentation of remaining populations (Bradford et al. 1993, Knapp and Matthews 2000, Vredenburg 2004, Finlay and Vredenburg 2007).

The second factor is the recent spread of the amphibian chytrid fungus (*Batrachochytrium dendrobatidis*), a recently discovered fungal pathogen (Longcore et al. 1999) that causes a highly infectious disease – chytridiomycosis – in many amphibian species. Studies indicate amphibian chytrid fungus recently spread into the Sierra Nevada (Morgan et al. 2007), and has infected nearly all remaining MYLF populations, including those in SEKI and Yosemite National Park (YOSE). Most MYLF populations severely declined within a few years after becoming infected and some populations were extirpated. Amphibian chytrid fungus has thus exacerbated nonnative trout-caused MYLF declines already in progress 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 Endangered Species Act (FWS 2007A).

Current studies indicate that both MYLF species are continuing to decline and are on trajectories toward extinction (Knapp et al. 2011). As a result, in 2012, *R. muscosa* was listed as endangered and *R. sierrae* was listed as threatened under the California Endangered Species Act (CFGC 2012), and in April 2014 both species were listed as endangered (FE) under the federal Endangered Species Act (ESA; FWS 2014A). SEKI is the only park that contains both species of MYLFs, making it a core zone for their restoration, recovery, and conservation.

To further investigate the effects of nonnative trout, researchers studied the response of MYLFs and other native species (e.g., aquatic invertebrates and zooplankton) when nonnative fish disappeared from historically fishless lakes due to stocking termination or experimental eradication. Results showed that native species quickly recovered toward pre-disturbance levels following the return of lakes to a fishless condition (Knapp et al. 2001, 2005, 2007; Vredenburg 2004; Knapp and Sarnelle 2008).

From 1997 to 1999, researchers experimentally showed that fish eradication using gill nets was feasible after they successfully eradicated nonnative fish from two of the parks' waterbodies (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 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 declining MYLFs.

From 2001 to 2013, SEKI removed 50,201 fish from targeted lakes and streams (NPS 2015A, NPS unpublished data). By 2013, SEKI had fully eradicated fish from 10 waterbodies, nearly eradicated fish from 9 waterbodies, and began fish eradications in 4 waterbodies (initiated in 2012). MYLFs in nine of these waterbodies remained disease-free three years after fish removal. During this time average tadpole density in these 9 waterbodies increased by 13-fold (from 0.8 to 10.1 per 10 m of shoreline), while average frog density increased by 14-fold (from 0.8 to 11.1 per 10 m of shoreline) (NPS 2011A; Figure (3). One waterbody showed an overall 49-fold increase from 0.9 to 43.9 individuals per 32 ft (10 m) of shoreline. Several of these MYLF populations are now the largest in the Sierra Nevada. These results show that the eradication of nonnative fish using gill nets and electrofishers is feasible and beneficial to MYLFs and other native species at the local scale of individual or small groups of waterbodies.

Although SEKI has improved MYLF populations in three restoration basins, all remaining MYLF populations are still extremely vulnerable to extirpation due to multiple threats, and thus are in urgent need of intervention. First, many populations occupy large basins in which multiple large lakes contain nonnative trout, and MYLFs are restricted to small and/or shallow ponds. The trout severely limit frog distribution and abundance by excluding frogs from many perennial lake habitats, often restricting frogs to small and/or ephemeral pond habitat that is highly vulnerable to climate change. These ponds can completely dry up in even relatively short droughts, which can have deleterious effects to MYLF recruitment (Lacan et al. 2008). When smaller ponds (into which MYLFs have been restricted by fish) dry up, multiple cohorts of MYLF tadpoles are lost, and populations already suppressed by trout can be quickly extirpated. In addition, shallow ponds can freeze solid during atypical climate patterns, as occurred in SEKI during the winter of 2011 to 2012. This event appears to have killed most of the adult MYLFs that remained in at least one basin in the parks. Prioritizing the eradication of nonnative trout would allow MYLF populations to expand (Knapp et al. 2007) and recolonize large lake habitats that can better withstand climatic variation.

Second, nearly all remaining MYLF populations in areas feasible for restoration in SEKI are infected with amphibian chytrid fungus. MYLF populations in SEKI restored in the recent past were disease-free and primarily being suppressed only by nonnative trout. Eradicating trout then allowed the MYLF populations to easily expand in size because amphibian chytrid fungus and its subsequent impacts were not yet present. Now, however, as the amphibian chytrid fungus has spread throughout much more of the landscape, many of SEKI’s MYLF populations have experienced severe die-offs and the surviving remnant populations have very low survival and recruitment from year to year (Rachowicz et al. 2006, Vredenburg et al. 2007, Vredenburg et al. 2010A). These small frog populations are thus extremely vulnerable to extirpation. In addition to trout removal, these MYLF populations would likely benefit from an emerging disease treatment technique using antifungal agents, designed to increase short-term survival and hopefully long-term recruitment, thus changing the outcome for many frogs from mortality to persistence. Preliminary results of several field trials conducted in SEKI from 2009 to 2015 show promise for future management application.

A few MYLF populations are showing evidence of persistence – surviving and reproducing while continuing to be infected (Vredenburg et al. 2010A; 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 amphibian chytrid fungus by improving their ability to develop resistance to the disease instead of being extirpated.

Management Alternatives

A total of 11 action alternatives and the no action alternative were originally identified in the Restoration of Native Species in High Elevation Aquatic Ecosystems Plan and Draft Environmental Impact Statement (Restoration Plan/DEIS; NPS 2013A). A twelfth action alternative, using drought conditions to allow for the exclusive use of physical fish removal methods, was suggested during public comment of the Restoration Plan/DEIS and was also considered. Of these, nine action alternatives were dismissed from further consideration as described in chapter 2. Three action alternatives and the no action alternative were carried forward for further analysis in this Restoration Plan/FEIS.

Alternative A (the no action alternative) describes current management of high elevation aquatic ecosystems in SEKI and provides a baseline for comparison against the action alternatives. Alternatives B, C, and D (action alternatives) describe a range of reasonable and feasible approaches that partially or fully (1) meet the purpose and need for action and (2) achieve the plan objectives.

In addition, there are a number of activities described as common to all action alternatives. These include (1) the development of criteria for selection of basins for restoration; (2) conducting site assessments for proposed fish eradication areas; (3) the development of criteria for selection of crew camp locations; (4) use of helicopters and stock to support project field actions; (5) monitoring restoration work and ecosystem responses; (6) ecosystem restoration and management, including protecting and expanding extant populations of MYLFs, and reintroducing MYLFs to locations where populations have recently been extirpated; (7) practicing adaptive management; (8) continuing research; and (9) fish disposal methods.

The following selection process was used to determine which basins and individual waterbodies should be proposed for aquatic ecosystem restoration in this Restoration Plan/FEIS. Initial basin/site selections were based on examination of maps, staff familiarity with the parks, and discussions with other research scientists. A number of criteria were then developed and used to identify project sites that would be feasible for nonnative fish eradication, and have the best potential for success, while providing for crew safety (Table 1). For example, all proposed treatment sites are located at the upstream ends of each basin so that no fish would remain above each treatment area. Second, all proposed sites also have a natural cascade at the downstream end of the treatment area that would act as a fish barrier and prevent fish remaining in untreated areas downstream from recolonizing the treatment area. Third, all proposed sites are safely accessible by crews on foot and by helicopter or stock for transport of equipment and supplies. Fourth, a total number of fish eradication waterbodies was targeted that could be completed in the 25 to 35 year time frame of this project. While conservation of MYLFs, other native species, and ecosystem processes is identified as the highest priority consideration, SEKI also is maintaining recreational fishing opportunities where those opportunities do not compromise the recovery and conservation of MYLFs and other native species.

Table 1 shows the basin selection criteria used to determine which waterbodies should be considered for proposed aquatic ecosystem restoration:

- First, waterbodies possessing the characteristics listed under “Rule-out” in Table 1 were removed from consideration for additional nonnative fish eradication.
- Second, for all remaining waterbodies, those that possessed the characteristics described in the left column under “Other Consideration Factors” were identified as higher priority for additional nonnative fish eradication because their inclusion helped achieve multiple project objectives. Waterbodies from this group that fell under the right column were identified as lower priority for additional nonnative fish eradication because their inclusion would achieve fewer project objectives.
- Third, from the group of waterbodies identified as higher priority for additional nonnative fish eradication, waterbodies were selected from across the parks to ensure the proposed sites would restore and conserve native species, genetic diversity, and ecosystem processes in areas encompassing the geographic and elevational diversity contained within the parks.

Table 1. Basin Selection Criteria

Favorable	Rule-out
Elevation is between 6,000 and 12,000 ft (1,800 and 3,700 m).	Elevation is under 6,000 ft (1,800 m) or above 12,000 ft (3,700 m). Lake basins in SEKI typically do not occur outside of these elevations.
Adequate downstream barrier (large waterfall or long, steep cascade) exists naturally, or the stream could be altered by blasting to create a vertical fish barrier, which would prevent fish from recolonizing restoration area. Barrier potential would be assessed prior to the onset of restoration.	No adequate downstream fish barrier exists naturally and there is no potential to create a barrier by blasting. Fish are observed breaching all possible barriers and would likely continue breaching even after blasting.
Fish eradication is feasible from a logistical standpoint. Habitat structure would allow fish eradication without extreme difficulty, and site can be safely accessed by field crews.	Fish eradication is considered infeasible from a logistical standpoint. Habitat structure is so complex that it would be extremely difficult to eradicate fish, and/or site cannot be safely accessed by field crews.
Crew presence unlikely to jeopardize the existence of known threatened or endangered plant or wildlife species.	Crew presence could jeopardize the existence of known threatened or endangered plant or wildlife species.
Evidence of current or recent populations within natural distribution of MYLFs (includes sites where frogs recently died out due to disease).	There is no evidence of current or past MYLF populations. Removal of fish would benefit other native species.
Other Consideration Factors	
Achieves Comparatively More Objectives	**Achieves Comparatively Fewer Objectives**
Restores/conserves genetic diversity of MYLFs within SEKI – several sites restored within each of three major genetic groups.	Total number of restoration sites is imbalanced with respect to genetic diversity of MYLFs within SEKI.
Restores/conserves spatial representation MYLFs within SEKI – sites restored across park latitudes and longitudes.	Total number of restoration sites is imbalanced with respect to historic representation of MYLFs within SEKI.
Groupings of waterways appropriate for treatment. For basins in which some fish lakes would remain, restoration lakes are at top of basin. Several entire basins are restored, spread across SEKI.	Groups of waterways not considered appropriate for treatment. For basins in which some fish lakes would remain, restoration lakes are at middle or bottom of basin. No entire basins are restored in SEKI.
For individual lake selection, recreational fishing value of lake is medium to low – not a very popular or trophy fishery. For the overall project, fishing opportunities within SEKI continue to exist that satisfy a range of visitor values, including multiple fish lakes within each of the following categories: 1) near trailheads for easy access; 2) in remote basins for solitude; 3) having large fish for a trophy experience; 4) having many fish for a high-catch experience.	For individual lake selection, recreational fishing value of lake is high – a very popular or trophy fishery. For the overall project, multiple fish lakes within each of the following categories do not continue to exist within SEKI: 1) near trailheads for easy access; 2) in remote basins for solitude; 3) having large fish for a trophy experience; 4) having many fish for a high-catch experience.
Other known threats not an issue.	Other threats make site less desirable. For example, considering piscicide use in areas close to human populations.

The four management alternatives are summarized below. See chapter 2 for a complete description.

Alternative A: No Action

Under the no action alternative, the existing high elevation aquatic ecosystem restoration effort for 25 waterbodies and 3.7 mi of streams in seven basins 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. Research on native species, ecological processes, and their stressors would continue in accordance with NPS policy. After all treatments are completed, self-sustaining nonnative trout populations would continue to exist in 550 waterbodies (252 lakes, 235 ponds, 63 marshes) and hundreds of miles of stream.

Alternative B: Prescription Treatment (Physical and Piscicide) Preceding Restoration (NPS Preferred Alternative)
Under this alternative, a prescription (detailed plan of action) for restoration would be developed for each proposed restoration area based on the criteria for basin selection, pre-treatment surveys, habitat size, basin topography, wilderness values, visitor use, and field crew safety. Prescriptions would consider the actual distribution of fish, results of amphibian surveys, and whether any unique habitats were detected (such as springs). Physical treatment (gill netting, electrofishing, trapping, disturbing redds, and/or temporarily covering spawning habitat with boulders) would be utilized. Piscicide treatment methods would be considered for waterbodies determined infeasible for physical treatment.

Based on current knowledge of the proposed fish eradication sites, physical treatment would be applied in 52 waterbodies (27 lakes, 24 ponds, 1 marsh; total of 492 ac/199 ha) and 15 mi (25 km) of streams in 17 basins, and piscicide treatment would be applied in 33 waterbodies (4 lakes, 25 ponds, and 4 marshes; total of 142 ac/57 ha) and 16 mi (25 km) of streams in 9 basins. In addition, any unsurveyed habitat adjacent to treated lakes, ponds, marshes, and streams found to contain nonnative fish would also require treatment in order to eradicate fish from the geographic area. Although the total acreage requiring treatment may change slightly based on site-specific survey information and prescription development, the number of waterbodies and stream miles identified for treatment represents the maximum number of waterbodies to be treated in this alternative. If selected, piscicide treatments would not start until 2017 or 2018. After all treatments are completed, self-sustaining nonnative trout populations would continue to exist in 465 waterbodies (221 lakes, 186 ponds, 58 marshes) and hundreds of miles of stream.

Alternative C: Physical Treatment Preceding Restoration
Alternative C would use physical treatment methods only to eradicate nonnative fish by gill netting, electrofishing, trapping, disturbing and/or covering redds, and blasting rock to create vertical fish barriers. In comparison to alternative B, excluded from the list of proposed restoration waterbodies are long reaches of stream, several large lakes, and interconnected lake complexes that are too large for effective physical treatment. Under this alternative, a prescription for restoration would be developed for each proposed restoration area based on the criteria for basin selection, pre-treatment surveys, habitat size, basin topography, wilderness values, visitor use, field crew safety, and the actual distribution of fish and amphibians.

The following locations would be specific to this alternative. Physical treatment methods would be applied in 52 waterbodies (27 lakes, 24 ponds, and 1 marsh; total of 492 ac/199 ha) and 15 mi (25 km) of streams contained in 17 basins. In addition, any unsurveyed habitat adjacent to treated lakes, ponds, marshes, and streams found to contain nonnative fish would be treated to eradicate fish from the entire scope of the restoration area. Although the total acreage requiring treatment may change slightly based on site-specific survey information and prescription development, the number of waterbodies and stream miles identified for treatment represents the maximum number of waterbodies to be treated in this alternative. After all treatments are completed, self-sustaining nonnative trout populations would continue to exist in 498 waterbodies (225 lakes, 211 ponds, 62 marshes) and hundreds of miles of stream.

Alternative D: Piscicide Treatment Preceding Restoration
Alternative D emphasizes speed in recovering habitat because MYLF populations are declining rapidly. To achieve this speed, only piscicide treatment would be used for nonnative fish eradication. Properly applied, piscicides can eliminate fish from targeted waterbodies in 1 to 2 years, in contrast to physical treatment methods which can take up to 6 years for lakes and up to 10 years for streams (NPS 2012A). A

prescription for treatment would be developed as described in alternative B. Based on initial examination of maps, staff familiarity with the park, and discussions with other scientists, piscicide treatment would be used for 85 waterbodies (31 lakes, 49 ponds, and 5 marshes; total of 634 ac/257 ha), approximately 31 mi (50 km) of streams, and 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 waterbodies and stream miles identified for treatment represents the maximum number of waterbodies to be treated in this alternative. If selected, no piscicide treatments would occur until 2017, at the earliest. After all treatments are completed, self-sustaining nonnative trout populations would continue to exist in 465 waterbodies (221 lakes, 186 ponds, 58 marshes) and hundreds of miles of stream.

Issues and Impact Topics

The following issues and impact topics were identified based on internal and public scoping; federal laws, regulations, and executive orders; NPS *Management Policies 2006*; site visits; and NPS knowledge of limited or easily impacted resources. These topics were evaluated in this Restoration Plan/EIS in "Chapter 4 – Environmental Consequences." A summary of the impacts from each alternative are described in Table 2.

Special-Status Species. This plan would affect the two species of MYLFs that are currently listed as endangered under the ESA. Therefore, MYLFs will be further evaluated in this document.

Several special-status species or species of management concern occur in or near the proposed project areas, and may be affected by project activities. Species to be evaluated in this document include the Yosemite toad (*Anaxyrus [Bufo] canorus*), the Little Kern golden trout (*Oncorhynchus mykiss whitei),* and the Sierra Nevada bighorn sheep (*Ovis canadensis sierrae*).

Wildlife (including vertebrates and invertebrates). Vertebrates and invertebrates would be affected by nonnative fish removal. If piscicides are used, fish removed from the proposed restoration areas would be left in the environment, thus providing a short-term nonnative nutrient and food source for wildlife.

Wild and Scenic Rivers. This plan includes project work that would occur near designated and eligible/suitable Wild and Scenic Rivers and one alternative proposes to alter a tributary of a designated wild and scenic river.

Water Quality. Project activities and techniques considered in the alternatives could affect water quality.

Natural Soundscapes. Work associated with the implementation of project activities would create human-generated noise during the project work.

Wilderness Character. This plan would occur within designated wilderness. Activities occurring in wilderness have the potential to impact wilderness character and values, primarily through impacting the untrammeled quality of wilderness character in the short term, and benefitting the natural quality of wilderness in the long term.

Health and Safety. The safety of the parks' visitors and employees could be affected by components described in this plan.

Visitor Experience and Recreational Opportunities. Elements considered in this plan would have an effect on visitor experience and recreational opportunities. Recreational opportunities, such as angling, could be eliminated from proposed restoration sites and replaced with other opportunities, such as opportunities to view native wildlife characteristic of pristine lakes.

Table 2. Summary of Alternatives Table

	Actions Common to All Alternatives	Alternative A: No Action	Alternative B: Prescription Treatment (Physical and Piscicide) Preceding Restoration (Preferred Alternative)	Alternative C: Physical Treatment Preceding Restoration	Alternative D: Piscicide Treatment Preceding Restoration
Summary of Alternatives	• Site assessments would occur for each restoration basin to confirm the treatment approach. • Crew camps would be established for each project area. • Helicopters and/or stock would be utilized to transport tools and equipment. • Reintroduction of mountain yellow-legged frogs (MYLF) would be considered. • Monitoring, research and scientific studies would continue to inform project, and may result in the expansion of management tools available for future management activities. • Captured fish would be disposed of by sinking them in lakes.	This alternative limits nonnative fish eradications to 25 previously approved waterbodies, including 2 waterbodies for experimental restoration by researchers from 1997 to 1999, and 23 waterbodies for preliminary restoration by SEKI from 2001 to 2017. No new waterbodies for nonnative fish eradication are proposed.	Nonnative fish would be eradicated from an additional 85 waterbodies and 31 mi (50 km) of stream in 21 basins, including 52 waterbodies and 15 mi (25 km) of stream using physical treatment methods in 17 basins; and 33 waterbodies and 16 mi (25 km) of streams using piscicide treatment in 9 basins. MYLFs and other native species would be restored to these 85 waterbodies using natural recolonization where adjacent source populations exist, and reintroductions where adjacent source populations do not exist.	Nonnative fish would be eradicated from an additional 52 waterbodies and 15 mi (25 km) of stream in 17 basins using physical treatment methods. Blasting is considered in up to five locations to create vertical fish barriers in streams. MYLFs and other native species would be restored to these 52 waterbodies using natural recolonization where adjacent source populations exist, and reintroductions where adjacent source populations do not exist.	Nonnative fish would be eradicated from an additional 85 waterbodies and 31 mi (50 km) of stream in 21 basins using piscicide treatment only. MYLFs and other native species would be restored to these 85 waterbodies using natural recolonization where adjacent source populations exist, and reintroductions where adjacent source populations do not exist.

Table 3. Impact Summary Table

Impact Topic	Actions Common to All Alternatives	Summary of Impacts Alternative A: No Action	Summary of Impacts Alternative B: Prescription Treatment (Physical and Piscicide) Preceding Restoration (Preferred Alternative)	Summary of Impacts Alternative C: Physical Treatment Preceding Restoration	Summary of Impacts Alternative D: Piscicide Treatment Preceding Restoration
Special-Status Species *Mountain Yellow-legged Frogs (MYLF)* *Yosemite Toad* *Little Kern Golden Trout* *Sierra Nevada Bighorn Sheep*	• The establishment and use of crew camps would have no effect on special status species. • The use of helicopter and/or stock to support crew camps would have no effect on MYLF, Yosemite toad and Little Kern golden trout. The use of helicopters may affect, but is not likely to adversely affect Sierra Nevada bighorn sheep due to potential for flight responses. The use of stock would have no effect on bighorn sheep. • The restoration of MYLF (1) would have no effect on Yosemite toad and Little Kern golden trout; (2) may affect, but is not likely to adversely affect bighorn sheep due to potential for flight responses due to helicopter use for restoration activities; and (3) would have short-term adverse effects and long-term beneficial effects on MYLF. • Relocation of garter snakes from MYLF reintroduction and translocation sites would have short-term beneficial effects on MYLFs by removing immediate threats from predation and long-term beneficial effects on MYLF as populations become established.	MYLF: • *may affect, likely to adversely affect* from gill netting and electrofishing in 25 waterbodies and 3.7 mi (6.0 km) of streams in seven basins, due to the potential for disturbance, injury or mortality to individuals. • *long-term beneficial effects* in 25 waterbodies and 3.7 mi (6.0 km) of streams contained in seven basins, due to expected increases in existing populations to a larger (less-vulnerable) size in response to nonnative trout removal, and the reestablishments of populations in restored habitat. • *No effect* on Yosemite toad, Little Kern golden trout, and Sierra Nevada bighorn sheep.	MYLF: • *may affect, likely to adversely affect* from gill netting and electrofishing in an additional 52 waterbodies and 15 mi (25 km) of streams in 17 basins, and from piscicide use in an additional 33 waterbodies and 16 mi (25 km) of streams in 9 basins, due to the potential for disturbance, injury or mortality to individuals. • *long-term beneficial effects* in an additional 85 treated waterbodies and 31 mi (50 km) of streams contained in 21 basins, due to expected increases in existing populations to a larger (less-vulnerable) size in response to nonnative trout removal, and the reestablishments of populations in restored habitat. • Yosemite toad: *no effect* in 19 of the 21 treated basins; *may affect, likely to adversely affect* in Upper Evolution and McGee. • Little Kern golden trout: *no effect* in 20 of the 21 treated basins; *may affect, likely to adversely affect* in Crytes due to the eradication of this population of Little Kern	MYLF: • *may affect, likely to adversely affect* from gill netting and electrofishing in an additional 52 waterbodies and 15 mi (25 km) of streams in 17 basins, and potentially from blasting in up to five locations, due to the potential for disturbance, injury or mortality to individuals. • *long-term beneficial effects* in an additional 52 treated waterbodies and 15 mi (25 km) of streams contained in 17 basins, due to expected increases in existing populations to a larger (less-vulnerable) size in response to nonnative trout removal, and the reestablishments of populations in restored habitat. • Yosemite toad: *no effect* in 15 of the 17 treated basins; *may affect, likely to adversely affect* in Upper Evolution and McGee. • Little Kern golden trout: *no effect* in 16 of the 17 treated basins; *may affect, likely to adversely affect* in Crytes due to the eradication of this population of Little Kern	MYLF: • *may affect, likely to adversely affect* from piscicide use in an additional 85 waterbodies and 31 mi (50 km) of streams in 21 basins, due to the potential for disturbance, injury or mortality to individuals. • *long-term beneficial* effects in an additional 85 treated waterbodies and 31 mi (50 km) of streams contained in 21 basins, due to expected increases in existing populations to a larger (less-vulnerable) size in response to nonnative trout removal, and the reestablishments of populations in restored habitat. • Yosemite toad: *no effect* in 19 of the 21 treated basins; *may affect, likely to adversely affect* in Upper Evolution and McGee. • Little Kern golden trout: *no effect* in 20 of the 21 treated basins; *may affect, likely to adversely affect* in Crytes due to the eradication of this population of Little Kern golden trout.

Impact Topic	Actions Common to All Alternatives	Summary of Impacts Alternative A: No Action	Summary of Impacts Alternative B: Prescription Treatment (Physical and Piscicide) Preceding Restoration (Preferred Alternative)	Summary of Impacts Alternative C: Physical Treatment Preceding Restoration	Summary of Impacts Alternative D: Piscicide Treatment Preceding Restoration
	Garter snakes would not be relocated to areas containing populations of MYLFs or Yosemite toads. Therefore, moving garter snakes would have no effect on Sierra Nevada bighorn sheep, Little Kern golden trout, or Yosemite toad. • Monitoring, research, and scientific study would have no effect on Yosemite toad, Little Kern golden trout, and Sierra Nevada bighorn sheep. Handling some individual MYLF may adversely affect individual frogs, but there would be long-term beneficial effects from increased resistance to chytrid fungus. • Fish disposal would have no adverse effects on special status species and short-term beneficial effects on MYLF and Yosemite toads from nutrient pulses related to fish decomposition.		golden trout. •Sierra Nevada bighorn sheep: *no effect* in 19 of the 21 treated basins; *may affect, not likely to adversely affect* in Sixty Lake and Laurel.	golden trout. • Sierra Nevada bighorn sheep: *no effect*	• Sierra Nevada bighorn sheep: *no effect* in 19 of the 21 treated basins; *may affect, not likely to adversely affect* in Sixty Lake and Laurel.
Wildlife *Vertebrates*	**Vertebrates** • The establishment and use of crew camps may cause short-term disturbance and flight response, resulting in short-term negligible adverse effects. • Helicopter and stock use would result in short-term disturbances and flights responses, resulting in short-term negligible adverse effects to some vertebrates, and no effect to others. . • Fish disposal would result in both short and long-term negligible effects on vertebrates due to changes in nutrient and water chemistry, and short- and long-term beneficial effects from increased food sources during fish decomposition. • Restoration, research, and scientific studies would have short-term negligible adverse effects from disturbance on all vertebrates but garter snakes; short-term minor adverse effects on local garter snake populations from relocations (negligible impacts at park scale); and long-term beneficial effects on all vertebrates from restoration.	**Vertebrates** • Short-term moderate adverse effects on vertebrates from gill netting and electrofishing in 25 waterbodies and 3.7 mi (6.0 km) of streams in seven basins, due to the potential for disturbance, injury or mortality to individuals. • Long-term beneficial effects on vertebrates in 25 treated waterbodies and 3.7 mi (6.0 km) of streams contained in seven basins, due to increased natural food sources in response to nonnative trout removal.	**Vertebrates** • Short-term moderate adverse effects on vertebrates from gill netting and electrofishing in an additional 52 waterbodies and 15 mi (25 km) of streams in 17 basins, and from piscicide use in an additional 33 waterbodies and 16 miles (25 km) of streams in 9 basins, due to the potential for disturbance, injury or mortality to individuals. • Long-term beneficial effects on vertebrates in an additional 85 treated waterbodies and 31 mi (50 km) of streams contained in 21 basins, due to increased natural food sources in response to nonnative trout removal.	**Vertebrates** • Short-term moderate adverse effects on vertebrates from gill netting and electrofishing in an additional 52 waterbodies and 15 mi (25 km) of streams in 17 basins, and potentially from blasting in up to five loacations, due to the potential for disturbance, injury or mortality to individuals. • Long-term beneficial effects on vertebrates in an additional 52 treated waterbodies and 15 mi (25 km) of streams contained in 17 basins, due to increased natural food sources in response to nonnative trout removal.	**Vertebrates** • Short-term moderate adverse effects on vertebrates from piscicide use in an additional 85 waterbodies and 31 mi (50 km) of streams in 21 basins, due to the potential for disturbance, injury or mortality to individuals. • Long-term beneficial effects on vertebrates in an additional 85 treated waterbodies and 31 mi (50 km) of streams contained in 21 basins, due to increased natural food sources in response to nonnative trout removal.
Invertebrates	**Invertebrates** • The establishment and use of crew camps would result in negligible adverse effects on invertebrates associated with disturbance, flight response, and trampling. • Helicopter and stock use would result in no to negligible effects. • Fish disposal activities would result in negligible adverse effects due to disturbance,	**Invertebrates** • Short-term negligible to minor adverse effects on invertebrates from gill netting and electrofising in 25 waterbodies and 3.7 mi (6.0 km) of streams in seven basins, due to the potential for disturbance, injury or mortality to individuals. • Long-term beneficial effects on invertebrates in 25 treated waterbodies and 3.7 mi (6.0 km) of streams contained in seven basins, due to	**Invertebrates** • Short-term negligible to minor adverse effects on invertebrates from gill netting and electrofishing in an additional 52 waterbodies and 15 mi (25 km) of streams in 17 basins, due to the potential for disturbance, injury, or mortality to individuals. • Short-term major adverse effects on invertebrates from piscicide use in an additional 33 waterbodies and 16 mi (25 km)	**Invertebrates** • Short-term negligible to minor adverse effects on invertebrates from gill netting and electrofishing in an additional 52 waterbodies and 15 mi (25 km) of streams in 17 basins, and potentially from blasting in up to five locations, due to the potential for disturbance, injury, or mortality to individuals. • Long-term beneficial effects on invertebrates in an additional 52 waterbodies and 15 mi	**Invertebrates** • Short-term major adverse effects on invertebrates from piscicide use in an additional 85 waterbodies and 31 mi (50 km) of streams in 21 basins, due to disturbance, injury, or mortality to individuals and reduction in abundance and diversity of populations. • Long-term moderate adverse effects on invertebrates from piscicide use in an

Impact Topic	Actions Common to All Alternatives	Summary of Impacts Alternative A: No Action	Summary of Impacts Alternative B: Prescription Treatment (Physical and Piscicide) Preceding Restoration (Preferred Alternative)	Summary of Impacts Alternative C: Physical Treatment Preceding Restoration	Summary of Impacts Alternative D: Piscicide Treatment Preceding Restoration
	and beneficial effects due to increases in nutrients released via fish decomposition. • Restoration, research, and scientific studies would have short-term negligible adverse effects on invertebrates from disturbance, and long-term beneficial effects from ecosystem restoration.	invertebrate populations increasing in abundance, distribution and diversity in response to nonnative trout removal.	of streams contained in 9 basins, due to disturbance, injury or mortality to individuals and reduction in abundance and diversity of populations. • Long-term moderate adverse effects on invertebrates from piscicide use in an additional 33 waterbodies and 16 mi (25 km) of streams contained in 9 basins, due to the potential for prolonged reduction in abundance and diversity of populations. • Long-term beneficial effects on invertebrates in an additional 85 treated waterbodies and 31 mi (50 km) of streams contained in 21 basins, due to invertebrate populations increasing in abundance, distribution and diversity in response to nonnative trout removal.	(25 km) of streams contained in 17 basins, due to invertebrate populations increasing in abundance, distribution and diversity in response to nonnative trout removal.	additional 85 waterbodies and 31 mi (50 km) of streams contained in 21 basins, due to the potential for prolonged reduction in abundance and diversity of populations. • Long-term beneficial effects on invertebrates in an additional 85 treated waterbodies and 31 mi (50 km) of streams contained in 21 basins, due to invertebrate populations increasing in abundance, distribution and diversity in response to nonnative trout removal.
Wild and Scenic Rivers	Crew camps, helicopter and stock use, and restoration, monitoring, research, and fish disposal would have no direct effects on wild and scenic rivers. In upper basin areas associated with wild and scenic rivers, there would be limited indirect effects on scenic values related to the presence of crews working and camping in project areas near tributaries to wild and scenic rivers. Recreational, fish, and wildlife values would be changed in the future as ecosystems are restored, primarily due to an increase in opportunities to view native wildlife. This would result in beneficial effects to associated wild and scenic rivers values.	There would be long-term adverse effects on recreational opportunities related to decreased fishing opportunities in upper basin areas that drain into wild and scenic rivers, and long-term beneficial effects on native wildlife populations, but to a lesser degree than alternatives B, C, and D.	There would be long-term adverse effects on recreational opportunities related to decreased recreation (fishing) in upper basin areas associated with wild and scenic rivers, and long-term beneficial effects on native wildlife populations.	There would be long-term adverse effects on recreational opportunities related to decreased recreation (fishing) in upper basin areas associated with wild and scenic rivers, and long-term beneficial effects on native wildlife populations, but to a lesser degree than alternatives B and D.	Same as alternative B.
Water Quality	• Crew camps would have a negligible effect on water quality due to a slight potential for upland sediment, food, and personal care items to reach waterways. • The use of helicopters would have no effect on water quality. Stock use would result in a negligible to minor adverse effect on water quality. • The restoration, monitoring, and research program would result in short-term negligible to minor adverse effects on a localized scale during project work; the long-term effects would be beneficial as healthy functioning native ecosystems are restored. • Impacts of fish disposal on water quality would be short-term, negligible to moderate and adverse based on the type of operation (whether gill netting or piscicide use) and the timing (more fish are caught during the early stages of the treatment)	This alternative would have short-term negligible adverse impacts on water quality due to slight increases in turbidity during project work from walking in and adjacent to waterbodies.	Physical treatments would result in short-term negligible adverse effects on water quality due to slight increases in turbidity during project work from walking in and adjacent to waterbodies. Piscicide treatments, including increased turbidity during project work and the application of rotenone to treated areas would result in short-term negligible to minor adverse impacts on water quality.	Physical treatments would result in short-term negligible adverse effects on water quality due to slight increases in turbidity during project work from walking in and adjacent to waterbodies and from blasting.	Piscicide treatments, including increased turbidity during project work and the application of rotenone to treated areas would result in short-term negligible to minor adverse impacts on water quality.

Impact Topic	Actions Common to All Alternatives	Summary of Impacts Alternative A: No Action	Summary of Impacts Alternative B: Prescription Treatment (Physical and Piscicide) Preceding Restoration (Preferred Alternative)	Summary of Impacts Alternative C: Physical Treatment Preceding Restoration	Summary of Impacts Alternative D: Piscicide Treatment Preceding Restoration
Wilderness Character (untrammeled, natural, undeveloped, opportunities for solitude or primitive and unconfined recreation, other features of value).	**Untrammeled:** • Crew Camps – No effect. • Use of Helicopter and Stock – No effect. • Restoration, Monitoring, and Research – Restoration would result in trammeling actions periodically for the life of the project (20 to 35 years). Monitoring and research sometimes result in trammeling actions, if there is intentional manipulation of the natural environment. • Fish Disposal - 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.	**Untrammeled:** There would continue to be trammeling actions at two basins until the current restoration project is completed in 2017. Trammeling actions include netting and electrofishing to remove nonnative fish from the lakes and streams within the project area.	**Untrammeled:** The project itself constitutes a long-term trammel as it would continue for the next 25 to 35 years. There would be site-specific trammeling associated with the removal of nonnative fish at up to six treatment sites per year, for several weeks each summer, over a one to seven year period, with some sites treated for up to 10 years. There would be additional trammeling associated with invertebrate sampling as part of pre- or post-treatment assessments at up to four sites per year, one to two weeks per site per summer, over a four year period. This alternative includes physical and piscicide treatments that involve trammeling actions at 85 waterbodies and 31 mi (50 km) of streams, plus connected fish-containing habitat (as necessary). This alternative results in more trammeling actions than alternative A and C, and the same as alternative D, but trammeling actions would occur over a longer time period under this alternative (up to 35 years vs. up to 20 years).	**Untrammeled:** The project itself constitutes a long-term trammel as it would continue for the next 25 to 35 years. There would be site-specific trammeling associated with the removal of nonnative fish at up to six treatment sites per year, for several weeks each summer, over a 5 to 7 year period, with some sites treated for up to 10 years. This alternative includes physical treatment that involves trammeling actions at 52 waterbodies and 15 mi (25 km) of streams, plus connected fish-containing habitat (as necessary). Blasting rock to create vertical fish barriers at up to five locations is an intentional manipulation of the stream substrate, resulting in a long-term manipulation of the biophysical environment and a permanent modification/trammel of the stream. This alternative results in more trammeling actions than alternative A, and fewer trammeling actions than alternatives B and D, but includes a permanent trammeling action.	**Untrammeled:** The project itself constitutes a long-term trammel as it would continue for the next 15 to 20 years. There would be site-specific trammeling associated with the removal of nonnative fish at up to two treatment sites per year, two to four weeks per site per summer, over a one to two year period for most piscicide treatments, and potentially up to three years for one or more of the largest piscicide treatments. There would be slight site-specific trammeling associated with invertebrate sampling as part of pre- or post-treatment assessments at up to four sites per year, one to two weeks per site per summer, over a four-year period. This alternative includes piscicide treatment that involves trammeling actions at 85 waterbodies and 31 mi (50 km) of streams, plus connected fish-containing habitat (as necessary). This alternative results in more trammeling actions in the short-term than all other alternatives and fewer trammeling actions in the long-term because treatment actions would be accomplished faster.
	Natural • Crew Camps - Small crews staying in one location for several weeks would 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. Areas have been shown to recover after project work thus there would be no long-term effect on the natural from crew camps. • Helicopters and Stock - Helicopters affect the natural quality of wilderness by causing disturbance and flight responses in wildlife causing short-term minor adverse effects. Stock use would result in short-term minor adverse effects from trampling and stock waste. • Restoration, Monitoring, and Research - Short-term minor to moderate adverse effects, but long-term beneficial effects on native ecosystems as species are prevented from going extinct, and ecosystem restoration is accomplished.	**Natural:** Long-term beneficial effects from restoring the natural ecosystem and processes in 25 waterbodies.	**Natural:** Long-term beneficial effects from restoring the natural quality of wilderness in 15% of the approximately 550 waterbodies that are known to contain nonnative fish populations. Short-term moderate to major adverse effects from the use of piscicides. This alternative results in more restoration of the natural quality (more treatment sites) than alternatives A and B, and the same level of restoration as alternative D, but alternative D would be accomplished in a shorter time period.	**Natural:** Long-term beneficial effects from restoring the natural quality of wilderness in 9% of the approximately 550 waterbodies that are known to contain nonnative fish populations. However, most long reaches of streams, large lakes, and interconnected lake complexes would not be treated and the natural quality of wilderness would continue to be adversely affected. Long-term minor to moderate adverse effects to the natural quality of wilderness due to blasting in up to five locations. This alternative results in more restoration of the natural quality (more treatment sites) than alternative A, but less than alternatives B and D.	**Natural:** Long-term beneficial effects of restoring the natural quality of wilderness in 15% of the 550 waterbodies known to contain nonnative fish populations. Short-term moderate to major adverse effect on the natural quality of wilderness from the use of piscicides. This alternative results in the most short-term adverse effects on the natural quality from the exclusive use of piscicides, and would result in the restoration of the same number of sites as alternative B, but restoration of the natural quality at treatment sites would be accomplished in a shorter time period.

Impact Topic	Actions Common to All Alternatives	Summary of Impacts Alternative A: No Action	Summary of Impacts Alternative B: Prescription Treatment (Physical and Piscicide) Preceding Restoration (Preferred Alternative)	Summary of Impacts Alternative C: Physical Treatment Preceding Restoration	Summary of Impacts Alternative D: Piscicide Treatment Preceding Restoration
	• Fish Disposal – There would be a short-term effect as a result of adding nutrients to the system as fish biodegrade, and also by providing an unnatural food source to native wildlife.				
	Undeveloped • Crew Camps - Short- term minor to moderate adverse effects from the presence of crew camps and associated installations and transport of supplies. • Helicopter and Stock Use – Helicopter flights would result in a short-term minor to moderate adverse effect. Stock use would have no effect. • Restoration, Monitoring, and Research – These activities could include temporary installations, resulting in minor to moderate short- and long-term adverse effects on undeveloped. • Fish Disposal – There is no effect on undeveloped.	**Undeveloped:** The tools used to accomplish the restoration (the installation of nets, storage lockers, and the use of helicopters) create short- to long-term minor to moderate adverse effects on the undeveloped quality of wilderness.	**Undeveloped:** The installation of gill nets, the presence of crew camps and storage lockers, the use of small electric pumps and motors associated with piscicide use, and the use of helicopters create short-term adverse effects on the undeveloped quality of wilderness. There would be up to six crew camps in wilderness per year, generally occupying each site periodically through the summer season for approximately six years per lake or pond treatment site, and up to 10 years at treatment sites with long or complex streams. This alternative results in the greatest effect on the undeveloped quality as more tools are used at more locations.	**Undeveloped:** The installation of gill nets, the presence of crew camps and storage lockers, blasting of streams to create barriers, and the use of helicopters create short-term adverse effects on the undeveloped quality of wilderness. There would be up to five temporary crew camps in wilderness per year, generally occupying each site for several weeks each season for approximately six years per site for lakes and ponds, and up to 10 years for sites with long or complex streams. Blasting would create a long-term minor adverse effect on the undeveloped quality of wilderness in up to five locations because "the imprint of man's work" (i.e. visible scarring) would remain. This alternative results in a greater effect on the undeveloped quality than alternative A and D, but fewer effects than alternative B, as fewer tools are used at fewer locations.	**Undeveloped:** The presence of crew camps and storage lockers, the use of small electric pumps and motors associated with piscicide use, and the use of helicopters create short-term adverse effects on the undeveloped quality of wilderness. There would be up to six temporary crew camps in wilderness per year, including up to two conducting piscicide treatment activities and up to four conducting pre- or post-treatment assessment activities. Treatment sites would be occupied for two to four weeks in the summer for up to one to two years per site for most piscicide treatments, and potentially up to three years for one or more of the largest piscicide treatments; assessment sites would be occupied for one to two weeks in the summer for up to four years per site. Short-term storage locker installations would be needed to secure piscicide in crew camps before use. Helicopter use would be similar to alternative B. This alternative results in the least impact on the undeveloped quality as fewer mechanized/motorized tools are used, there are fewer installations, and there would be no long-term "imprint of man's work" since there is no blasting included.
	Opportunities for solitude or primitive and unconfined recreation: • Crew Camps- The presence of crew camps in several locations in the wilderness would reduce opportunities for solitude in the project areas. • Helicopter and Stock Use – Helicopters would reduce opportunities for solitude and unconfined recreation on a temporary basis. Stock use could reduce opportunities for solitude on a temporary basis. • Restoration, Monitoring, and Research - The presence of crews associated with these activities would result in negligible to minor	**Opportunities for solitude or primitive and unconfined recreation:** Long-term minor adverse effects on opportunities for primitive recreation (e.g. angling) resulting from the eradication of nonnative trout from 25 of the parks' waterbodies. Negligible adverse effect on solitude from the presence of two to three person crews. Long-term beneficial effects from the restoration of healthy native ecosystems at treated sites, leading to enhanced opportunities for primitive recreation.	**Opportunities for solitude or primitive and unconfined recreation:** Negligible adverse effect on solitude from the presence of one to six crews comprising two to three persons for physical treatment methods, and eight to 15 people for most piscicide treatment methods, and potentially up to 16-25 people for one or more of the largest piscicide treatments. Long-term minor to moderate adverse effects on opportunities for primitive recreation (e.g. angling) resulting from reduced angling opportunities at 85 of the parks' waterbodies and 31 mi (50 km) of streams. Long-term beneficial effects from the	**Opportunities for solitude or primitive and unconfined recreation:** Negligible adverse effect on solitude from the presence of one to five crews comprising two to three persons. Long-term minor adverse effects on opportunities for primitive recreation (e.g. angling) resulting from the eradication of nonnative trout from 52 of the parks' waterbodies and 15 mi (25 km) of streams. Long-term beneficial effects from the restoration of healthy native ecosystems at treated sites, leading to enhanced opportunities for viewing native wildlife in wilderness	**Opportunities for solitude or primitive and unconfined recreation:** Negligible to minor adverse effect on solitude from the presence of one to two crews comprising eight to 15 people for two to four weeks over a one to two year period during most piscicide treatment activities, and potentially up to three years for one or more of the largest piscicide treatments. Negligible adverse effect on solitude from the presence of one to four crews comprised of two to four people for one to two weeks during pre- or post-treatment assessment activities. Long-term minor to moderate adverse effects on opportunities for primitive recreation (e.g.

Impact Topic	Actions Common to All Alternatives	Summary of Impacts Alternative A: No Action	Summary of Impacts Alternative B: Prescription Treatment (Physical and Piscicide) Preceding Restoration (Preferred Alternative)	Summary of Impacts Alternative C: Physical Treatment Preceding Restoration	Summary of Impacts Alternative D: Piscicide Treatment Preceding Restoration
	adverse effects on solitude. There would be minor adverse effects on opportunities for primitive recreation as a result of the loss of angling opportunities at restoration sites and long-term beneficial effects from restoring opportunities to view native wildlife. • Fish Disposal – No effect.		restoration of healthy native ecosystems at treated sites, leading to enhanced opportunities for primitive recreation. Short-term adverse effects on unconfined recreation from area closures due to the application of piscicides. This alternative changes opportunities for solitude or primitive and unconfined recreation more than alternatives A and C, but less than alternative D. Angling opportunities would be reduced in the same locations as alternative D, but at a slower rate. Native wildlife viewing would be increased at the same locations as alternative D, but at a slower rate.	This alternative changes opportunities for solitude or primitive and unconfined recreation more than alternative A, and less than alternatives B and D. Angling opportunities would be reduced in fewer locations than alternatives B and D. Native wildlife viewing opportunities would be available at fewer locations than alternatives B and D.	angling) resulting from the eradication of nonnative trout from 85 of the parks' waterbodies and 31 mi (50 km) of streams. Short-term adverse effects from area closures due to the application of piscicides. Long-term beneficial effects from the restoration of healthy native ecosystems at treated sites, leading to improved opportunities for viewing native wildlife in wilderness This alternative changes opportunities for solitude or primitive and unconfined recreation the most, as crews would be larger and more areas would be closed to visitor use during treatment activities. Angling opportunities would be reduced in the same locations as alternative B, but would be reduced at a faster rate. Native wildlife viewing opportunities would be available at more locations in a shorter time period than alternatives A, B, and C.
Natural Soundscapes	• Crew Camps - The presence of these camps may adversely affect the visitor experience for those who hear noise generated from the camp areas, but this noise would primarily be crew members talking and would be short-term, temporary and localized, resulting in short- term negligible adverse impacts on natural soundscapes. • Helicopter and Stock Use - the use of helicopters results in short-term moderate adverse effects on natural soundscapes within the project areas, and within and around transportation corridors (whether flight lines or trails) to the project areas, and the use of stock results in short-term minor adverse effects on natural soundscapes. • Restoration, Monitoring and Research - Most of the work associated with these activities does not generate noise above a normal speaking voice, resulting in short- to long-term negligible adverse effects on the natural soundscape in localized areas. • Fish Disposal - Most of the work related to fish disposal would not generate noise above a normal speaking voice, resulting in short- to long-term negligible adverse effects on the natural soundscape in localized areas.	Sounds made by crews would have a short-term negligible adverse impact on natural soundscapes in a localized area. As each restoration site is completed, natural sounds would be restored as native species return to the sites. This would improve the natural soundscapes in the restoration areas. Under this limited restoration alternative, components of the natural soundscape over much of the high elevation landscape, including frog vocalization in many areas of the parks, would be lost, resulting in a major adverse long-term effect.	Sounds made by crews would have a short-term negligible adverse impact on natural soundscapes in a localized area. As each restoration site is completed, natural sounds would be restored as native species return to the sites. This would improve the natural soundscapes in the restoration areas. The natural soundscape would be restored in more areas than alternatives A and C, and in the same number of areas as alternative D but at a slower rate.	Sounds made by crews would have a short-term negligible adverse impact on natural soundscapes in a localized area. As each restoration site is completed, natural sounds would be restored as native species return to the sites. This would improve the natural soundscapes in the restoration areas. Noise from blasting to create vertical fish barriers in up to five locations would result in a short-term minor to moderate adverse effect on the natural soundscape in a localized area. The natural soundscape would be restored in more areas than alternative A, but in fewer areas and at a slower rate than alternatives B and D.	Sounds made by crews would have a short-term negligible adverse impact on natural soundscapes in a localized area. As each restoration site is completed, natural sounds would be restored as native species return to the sites. This would improve the natural soundscapes in the restoration areas. The natural soundscape would be restored in more areas in alternatives A and C, and in the same areas but at a faster rate than alternative B.
Visitor and Employee Health and Safety	• Crew Camps – There are risks to employees associated with living in the wilderness, but risks are reduced by proper training and conducting job hazard analyses. There is no effect on public health and safety. • Helicopter and Stock Use – There are risks to	This alternative would result in no appreciable effect on visitor health and safety. Employee risks are mitigated, but employees still assume personal responsibility for their safety, whether on or off duty. There still could be risks to employee safety until the ongoing	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 a negligible threat to the health	The effects on visitor health and safety would be the same as alternative A except the duration of the project would be longer, and there would be more sites. In addition, there would be a negligible to low increase in risk to visitors due to blasting (if determined necessary) in up to	The effects of this alternative related to the use of piscicide treatments on visitor health and safety are the same as alternative B. Piscicide treatments increase the risk for crews slightly, but provide a long-term benefit by reducing total time exposed to work hazards

Impact Topic	**Actions Common to All Alternatives**	**Summary of Impacts** **Alternative A:** **No Action**	**Summary of Impacts** **Alternative B:** **Prescription Treatment (Physical and Piscicide) Preceding Restoration (Preferred Alternative)**	**Summary of Impacts** **Alternative C:** **Physical Treatment Preceding Restoration**	**Summary of Impacts** **Alternative D:** **Piscicide Treatment Preceding Restoration**
	employees associated with working around helicopters and stock. These risks are mitigated by proper training and the use of an experienced crew. There is no effect on public health and safety. • Restoration, Monitoring and Research - Crews working in the wilderness have the potential for accidents and injuries. This risk is mitigated through the implementation of standard practices, conducting job hazard analyses, and training employees on proper procedures. These project components would not affect public health and safety. • Fish Disposal - Crews working in the wilderness have the potential for accidents and injuries. This risk is mitigated through the implementation of standard practices, conducting job hazard analyses, and training employees on proper procedures. These project components would not affect public health and safety.	project work is completed, but the risks are low to moderate.	and safety of wilderness users and the parks' neighbors. For crews, the short-term risk of piscicide treatments is low to moderate, but the piscicide treatments provide a long-term benefit by reducing total exposure from an average of six years (field seasons) per lake treatment site and up to 10 years per sites with long or complex streams (during summer months) to two to four weeks each year over a one to two year period for most sites selected for piscicide treatment, and potentially up to three years for one or more of the largest piscicide treatments. Piscicide treatments increase the risk for crews slightly, but provide a long-term benefit by reducing total time exposed to work hazards.	five locations. The effects of this alternative on employee health and safety would be the same as described under alternative A, though the duration of the project would be longer and there would be more project sites, resulting in a slightly increased risk. In addition, there would be a slight increase in risk for crews performing blasting activities (if determined necessary) in up to five locations. Crew members could spend approximately 6 to 10 field seasons per treatment site for the duration of the project, which is expected to continue for the next 35 years.	from 6 to 10 years per site, to two to four weeks per site over a one to two year period for most treatments, and potentially up to three years for one or more of the largest treatments.
Visitor Experience and Recreational Opportunities	• Crew Camps - The likelihood of visitors seeing crew camps is slight, and would result in negligible short-term adverse effects to those few park visitors who happen to travel by the site. • Helicopter and Stock Use – The use of helicopters and stock can have a positive or negative effect on the visitor experience. Generally, the use of helicopters results in a short-term moderate adverse effect. The use of stock results in minor short-term adverse or beneficial effects. • Restoration, Monitoring and Research –The effects are negligible to minor and adverse, but as ecosystems are restored, the effects would be long-term and beneficial. • Fish Disposal –The presence of dead fish would result in short-term negligible to minor adverse effects.	Visitors may experience a slight change in recreational opportunities as a result of the ongoing program, primarily due to reduced angling opportunities and ecosystem restoration in the 25 treatment waterbodies. Effects would be short- and long-term negligible to minor adverse and beneficial.	Visitors would experience a moderate change in recreational opportunities as a result of expanding the existing program, primarily due to reduced angling opportunities and ecosystem restoration in the 21 additional treatment basins. Visitors to the restored waterbodies should notice the effects associated with this alternative. Effects would be short- and long-term minor to moderate and adverse and beneficial.	Visitors would experience a negligible to minor change in recreational opportunities as a result of expanding the existing program, primarily due to reduced angling opportunities and ecosystem restoration in the 17 treatment basins. Visitors to the restored waterbodies should notice the effects associated with this alternative. Effects would be short- and long-term minor to moderate and adverse and beneficial.	Impacts would be similar to alternative B except that this alternative would result in a greater number of short-term site closures, and take the least amount of time to complete, meaning that angling would be excluded sooner and opportunities for observing restored ecosystems would improve faster when compared to the other alternatives.

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ACRONYMS AND ABBREVIATIONS

The following acronyms and abbreviations are used in the text or in bibliographic citations.

Agencies and Organizations
ABC – American Bird Conservancy
BLM – Bureau of Land Management
CCC – Civilian Conservation Crew
CDF – California Department of Forestry and Fire
CDFW – California Department of Fish and Wildlife
CDPR – California Department of Pesticide Regulation
DOI – United States Department of the Interior
EPA – United States Environmental Protection Agency
FWS – United States Fish and Wildlife Service
GRBA – Great Basin National Park
GRSM – Great Smoky Mountains National Park
IUCN – International Union for Conservation of Nature
NOCA – North Cascades National Park Complex
NPS – United States National Park Service
SEKI – Sequoia and Kings Canyon National Parks
SNARL – Sierra Nevada Aquatic Research Laboratory
USFS – United States Forest Service
USGS – United States Geological Survey
YELL – Yellowstone National Park
YOSE – Yosemite National Park

Other Acronyms Used
aPAD – Acute Population Adjusted Dose
BLMS – BLM Sensitive
BMP – Sequoia and Kings Canyon National Parks Backcountry Management Plan, 1986
CC – California Candidate Species
CE – California Endangered
CEQ – Council on Environmental Quality
CEQA – California Environmental Quality Act
CESA – California Endangered Species Act
CNPS – California Native Plants Society
CP – California Protected
cPAD – Chronic Population Adjusted Dose
CSC – California Special Concern
CT – California Threatened
CWL – California Watch List
DEIS – Draft Environmental Impact Statement
DFS – Department of Forestry Sensitive
DGEE – Diethylene Glycol Ethyl Ether
DO – Dissolved Oxygen
DOC – Dissolved Oxygen Content
DPS – Distinct Population Segment
DWLOC – Drinking Water Level of Concern
EA – Environmental Assessment
EDWC – Estimated Drinking Water Concentration

EIS – Environmental Impact Statement
EPT – Ephemeroptera Plecoptera Trichoptera (three taxonomic orders of aquatic invertebrates)
ESA – United States Endangered Species Act of 1973, as amended
FC – Federal Sensitive (former C2)
FCS– Federal Candidate Species
FE – Federal Endangered
FS – Forest Service Sensitive
FT – Federal Threatened
FEIS – Final Environmental Impact Statement
GMP – Sequoia and Kings Canyon National Parks Final General Management Plan and Final Environmental Impact Statement, 2007
LC50 – median Lethal Concentration
LOC – Level of Concern
LOAEL – Lowest Observed Adverse Effect Level
MD – Management Directive
MOE – Margin of Exposure
MRA – Minimum Requirement Analysis
MYLF – Mountain Yellow-legged Frogs (*Rana muscosa* and *Rana sierra*,collectively)
N/A – Not Applicable
ND – Not Detectable
NEPA – National Environmental Policy Act of 1969
NF – National Forest
NMP – N-Methyl-Pyrrolidone
NOAEL – No Observed Adverse Effect Level
NOEL – No Observed Effect Level
NOI – Notice of Intent
NPDES – National Pollution Discharge Elimination System
NPOMA – National Park Omnibus Management Act
NTU – Nephelometric Turbidity Units
PPE – Personal Protective Equipment
PIT – Passive Integrated Transponder
R – Rare (California)
RfD – Reference Dose
RIVPACS – River Invertebrate Prediction and Classification System
RMP – Sequoia and Kings Canyon National Parks Natural and Cultural Resources Plan, 1999
SAR – Search and Rescue
SNYLF – Sierra Nevada Yellow-legged Frog (*Rana sierrae*; used by Yosemite National Park when referring to *R. sierrae* because *R. muscosa* does not occur in Yosemite National Park.)
UF – Uncertainty Factor
USC – United States Code

Unit Abbreviations

mm – millimeter
cm – centimeter
m – meter
km – kilometer
ft – foot/feet
mi – mile
μg – microgram
mg – milligram
g – gram
kg – kilogram
ml – milliliter
l – liter

lbs – pounds
ac – acre
ha – hectare
hr – hour
min – minute
°C – degrees Celsius
°F – degrees Fahrenheit
ppb – Parts Per Billion
ppm – Parts Per Million
ppt – Parts Per Trillion
SVL – Snout to Vent Length

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GLOSSARY

abundance – a measure of the total number of individuals of a particular species in a defined area, population, or community.

adaptive management – a principle that incorporates monitoring and research into conservation actions. Specifically, it is the integration of planning, management, and monitoring to test assumptions in order to adapt and learn. Also, a systematic process for continually improving management policies and practices by learning from the outcomes of operational programs.

adult –a sexually mature individual. In the case of mountain yellow-legged frogs, "adult" refers to a post-metamorphic individual, generally over 1.5 inches snout to vent length (SVL) and displaying secondary sexual characteristics (e.g., enlarged nuptial pads on the thumbs of adult male frogs).

algae – one-celled (phytoplankton) or multi-cellular plants either suspended in water (plankton) or attached to rocks and other substrates (periphyton). Algae are an essential part of the lake ecosystem and provide the food base for most lake organisms, including fish. Phytoplankton populations vary widely from day to day due to short individuallife cycles.

application concentration – the amount of a particular substance (e.g., rotenone) in a given amount of another substance (e.g., water) when applied to an aquatic system. For example, when a CFT Legumine™ formulation containing 5% rotenone active ingredient is used to remove undesirable fish from a waterbody, the Environmental Protection Agency requires that it is applied with the proper amount of product in relation to the volume of water being treated, such that the water dilutes the CFT Legumine™ to a concentration of no more than 1 part per million in streams (= 50 parts per billion rotenone) and 4 parts per million in lakes (= 200 parts per billion rotenone). Rotenone is so effective at causing mortality to fish that it can be applied at extremely low application concentrations.

amphibian chytrid fungus – the fungal pathogen (*Batrachochytrium dendrobatidis*), which causes a highly infectious disease (chytridiomycosis) in many amphibian species. It was first scientifically described in 1998 and has been shown to be a major factor contributing to global amphibian declines.

backcountry – more remote, roadless, and less intensely used park areas where the majority of use is by overnight campers who hike or ride stock. Backcountry includes federally designated wilderness.

basin – also called "lake basin" or "drainage basin." In this document, "basin" refers to a small water catchment area of management interest (also see "**watershed**").

benthic – relating to or characteristic of the bottom of a lake, deep river, or sea. The benthic community is composed of a wide range of plants, animal, and bacteria from all levels of the food web.

best available technology – technology that will help achieve efficient and economically viable facilities and services, while offering the greatest protection and environmental benefit for park visitors, employees, resources, and values.

biological integrity – the ability to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of a natural habitat of the region.

biota – the combined plant and animal life of a particular region.

climate change – the long-term shift in weather patterns in a specific region or globally, such as precipitation, temperatures, cloud cover, and other parameters. According to the scientific experts in the field of climatology, climate change is caused by human activities that have resulted in an increased concentration of greenhouse gases in our atmosphere, including carbon dioxide, water vapor, methane, ozone, and nitrous oxide.

community composition – The assortment of species or taxa that comprise an ecological community.

CFT Legumine™ – an emulsifiable liquid fish toxicant manufactured by Envincio, LLC. The active ingredient is rotenone (5.0%). The formula also includes a proprietary emulsifier and solvent package for chemical delivery in aquatic habitats.

chytridiomycosis – a highly infectious disease caused by the fungal pathogen (*Batrachochytrium dendrobatidis*), also known as amphibian chytrid fungus. This disease causes high rates of mortality in post-metamorphic mountain yellow legged frogs after aquatic zoospores penetrate the keratinized skin of animals or mouthparts of tadpoles.

conserve – to protect from loss or harm; preserve. Historically, the terms conserve, protect, and preserve have come collectively to embody the fundamental purpose of the NPS—preserving, protecting, and conserving the national park system.

copepod – a tiny crustacean that lives among plankton and is an important food source to many organisms.

critical habitat – specific areas within a geographical area occupied by a threatened or endangered species which contain those physical or biological features essential to the conservation of the species, and which may require special management considerations or protection; and specific areas outside the geographical area occupied by the species at the time of its listing, upon a determination by the Secretary of the Interior that such areas are essential for the conservation of the species. (See 16 USC 1342)

cultural landscape – a geographic area, including both cultural and natural resources and the wildlife or domestic animals therein, associated with an historic event, activity, or person, or exhibiting other cultural or aesthetic values. There are four non-mutually exclusive types of cultural landscapes: historic sites, historic designed landscapes, historic vernacular landscapes, and ethnographic landscapes.

cultural resource – an aspect of a cultural system that is valued by or significantly representative of a culture, or that contains significant information about a culture. A cultural resource may be a tangible entity or a cultural practice. Tangible cultural resources are categorized as districts, sites, buildings, structures, and objects for the National Register of Historic Places, and as archeological resources, cultural landscapes, structures, museum objects, and ethnographic resources for NPS management purposes.

distribution – the geographical area (i.e., range) within which a taxon or other group of organisms occurs.

diversity – the species richness, or number of species, of a community or area.

Draft Environmental Impact Statement (DEIS) – a document that describes and assesses the impacts of proposed alternative actions and is available for public comment for a minimum of 60 days.

ecological function – the services provided to an ecosystem by one of its components (e.g., organisms).

ecosystem – a discrete unit that consists of living and non-living parts, interacting to form a stable system. Fundamental concepts include the flow of energy via food-chains and food-webs, and the cycling of nutrients biogeochemically. Ecosystem principles can be applied at all scales. Principles that apply to an ephemeral pond, for example, apply equally to a lake, an ocean, or the whole planet.

effect – the result of actions on natural and cultural resources, aesthetics, economic, social, or human health and safety. Effects can be direct, indirect, or cumulative. Used interchangeably with “impact.”

enabling legislation – the legislation that establishes national parks and that can be modified by subsequent legislation. Enabling legislation often describes the park purpose–the special attributes that caused the areas to be set aside with the mandate to protect these resources in an unimpaired condition for future generations.

endangered species – any species that is in danger of extinction throughout all or a significant portion of its range. In this document, “endangered species” refers to an official federal designation under the U.S. Endangered Species Act of 1973 and/or an official state designation under the California Endangered Species Act of 1970.

endemic – species having a distribution that is restricted to a relatively small region.

ephemeral – (as in ephemeral stream): not holding perennial surface water; temporary.

extinct – a taxon having no living representative (i.e., died out).

extirpated – no longer present in an area. This could be the result of several environmental factors, including human activities.

Final Environmental Impact Statement (FEIS) – the document that responds to public comments on the draft environmental impact statement, including corrections and revisions as a result of public comment.

fishless conservation waterbody – a lake, pond or marsh known to be fishless and thus to be suitable habitat for restoration and conservation of native species including MYLFs.

floodplain – a flat region in the bottom of a valley that is, or historically was, influenced by river flooding.

frontcountry – areas that are easily accessible to visitors (as opposed to backcountry or wilderness) and that are more highly used, often by single-day visitors to the parks. The frontcountry contains developed park areas and is generally along or accessed by transportation corridors.

fry – a general term for any young fish.

general management plan – a legislatively required plan that usually guides park management for 15 to 20 years. It is accompanied by a draft and final environmental impact statement.

genetic barcode – also known as a DNA barcode – the usage of a genetic marker (i.e., gene or DNA sequence) in an organism’s DNA to identify it as belonging to a particular taxonomic (species) group.

genetic clade – a sub-group of organisms from among a larger group sharing common ancestry, not shared by the other organisms in the larger group.

global warming – refers to just one aspect of climate change - a rise in the earth's surface temperature.

impact – (see effect)

introduction – in regards to nonnative species, the intentional or unintentional escape, release, dissemination, or placement of a species into an ecosystem as a result of human activity**.**

invasive species – a nonnative species whose introduction does or is likely to cause economic or environmental harm or harm to human health. Invasive species display rapid growth and spread, establish over large areas, and persist.

invertebrate – an animal lacking a backbone, such as an arthropod, mollusc, annelid, coelenterate, etc. The invertebrates constitute an artificial division of the animal kingdom, comprising 95% of animal species and about thirty different phyla.

invertebrate drift – when invertebrate larvae in streams are dislodged from substrates by a disturbance such as a flood or piscicide treatment and carried downstream by flows.

juvenile – a young or sexually immature animal. A juvenile MYLF is a post-metamorphic frog, <40mm snout-vent length, which can take up to four years to grow from metamorphosis to sexually mature adult.

lake – a lenticular waterbody with surface area ≥1 hectare.

lentic – a nonflowing, standing or still body of fresh water, such as a lake or pond.

lotic – a flowing body of fresh water, such as a river or stream.

macroinvertebrate – any invertebrate that is large enough to be seen with the naked eye (with a body longer than 2 mm).

marsh – areas labelled as "marsh" in this document are not traditional marsh habitats (such as those found at lower elevations), which are frequently or continuously inundated with water. Rather, in the context of this document, a "marsh" refers to small and/or ephemeral wetlands; or wet meadows that often dry by late summer. These "marsh" areas may also contain small ponds, or streams flowing through areas with saturated soil and emergent vegetation. (In the context of marshes being targeted for nonnative fish removal, a majority of the area is ephemeral wetland that contains discrete areas of fish occupancy, such as a stream channel or small, shallow, ephemeral pond that becomes seasonally infiltrated by fish.)

minimum requirement – a documented process used by the NPS to determine the appropriateness of all actions affecting wilderness.

minimum tool – a use or activity, determined to be necessary to accomplish an essential task, which makes use of the least intrusive tool, equipment, device, force, regulation, or practice that will achieve the wilderness management objective.

mitigation – measures that are taken to reduce the intensity of an adverse impact. Examples include alternative actions that would avoid the impact, that would minimize the impact by limiting the magnitude of the action, that would rectify the impact by repairing, rehabilitating, or restoring a resource, that would reduce impacts through preservation or maintenance; or that would compensate for the impact through replacement or substitution (e.g., creating a wetland environment at another location).

native species – with respect to a particular ecosystem, a species that, other than as a result of an introduction, historically occurred or currently occurs in that ecosystem.

National Environmental Policy Act of 1969 (NEPA) – this public law requires federal agencies to look at alternatives for proposed major federal actions and to fully analyze the impacts of those alternatives on the human environment before a decision is made.

nonnative species – with respect to a particular ecosystem, any species, including its seeds, eggs, spores, or other biological material capable of propagating that species, that is not native to that ecosystem.

packstock – (see stock)

piscicide – a substance that is toxic to fish, and specifically defined as a pesticide whose intended function is to eliminate undesirable fish from a body of water. Rotenone and antimycin A are commonly used piscicides.

piscicidal concentration – (see application concentration)

plankton – minute pelagic organisms that drift or float passively with the current in a sea or lake, consisting chiefly of diatoms, protozoans, small crustaceans, and the eggs and larval stages of larger animals.

physical tools – tools used to physically eradicate fish from treatment areas, including gill nets, electrofishers and dipnets, shovels and boots to disturb redds, and blasting to change cascades into vertical waterfalls that can serve as fish barriers.

pond – a lenticular waterbody with surface area <1 hectare.

post-metamorphic – after an amphibian metamorphoses from the fully aquatic tadpole/larval stage to the final stage of development. Includes metamorphs, juveniles, and adults.

potassium permanganate – a dark purple salt ($KMnO_4$) used as an oxidizer and disinfectant. It is commonly used in fishery management to neutralize piscicides such as rotenone.

public involvement – public input sought in planning for public lands and required under the National Environmental Policy Act. Comment is sought at the initial scoping and at the DEIS stages. Substantive comment on the DEIS must be responded to in the FEIS.

Record of Decision (ROD) – a document that states the official decision for alternative actions proposed by agencies in a draft environmental impact statement and revised in a final environmental impact statement.

redd – a hollow in gravel, sand, or woody debris on stream and lake bottoms, scooped out and cleaned by spawning trout, salmon, or other fish as a place to deposit eggs (i.e., a fish egg nest).

refugia – a geographical region that has remained, or will remain, unaltered by a disturbance that is affecting surrounding regions, therefore forming a refuge for relict plants and animals.

reintroduction – intentional movement of an organism into a part of its native range from which it has disappeared or become extirpated in historic times.

rotenone – a selective, non-specific pesticide, primarily used to control insects and invasive fish species, with some acaricidal (i.e., lethal to some arachnids) properties. It is a naturally occurring compound found in the roots, seeds, and leaves of plants in the Leguminosae family. In the past, rotenone had been used residentially for insect control in gardens and for lice and tick control on pets, among other non-piscicidal uses. In 2006, registrants voluntarily requested that all uses of rotenone, except piscicidal, be revoked. The EPA reassessed the uses of rotenone and removed all uses other than piscicidal from the label, including agricultural, residential, pet, and livestock applications.

rotenolone – a primary decomposition product of rotenone, which possesses about half the toxicity of rotenone.

self-sustaining – for this plan/EIS, refers to reproducing fish that are able to maintain populations over time without further stocking**.**

special-status species – a species, subspecies, or distinct vertebrate population segment that has been added to the federal lists of endangered and threatened wildlife and plants as they appear in section 17 of Title 50 of the Code of Federal Regulations (50CFR 17.11 and 17.12).

species – a group of organisms all of which have a high degree of physical and genetic similarity, generally interbreed only among themselves, and show persistent differences from members of allied groups of organisms**.**

species composition – the types and number of species that occupy a particular area.

stock – animals such as horses, mules, donkeys, or llamas that can be ridden or used to carry supplies.

subadult – synonym for "juvenile."

substrate – the surface or material on or from which an organism lives, grows, or obtains its nourishment.

sustainable – the use of park resources and environments in a way that does not deplete or permanently damage them, thereby allowing the uses to continue for an extended time.

taxa (plural of "taxon") – a taxonomic group of any rank, such as a species, family, or class.

taxa richness (a.k.a., biodiversity) – The number of taxa present in a community, measured as the number of taxa in a given area.

threatened species – any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range. In this document, "threatened species" refers to an official federal designation under the U.S. Endangered Species Act of 1973 and/or an official state designation under the California Endangered Species Act of 1970.

translocation – the capture of living organisms from one location and transporting them to another location for release.

trophic cascade – influence of consumer organisms on those lower in the food web with alternating effects at each trophic level; a.k.a., top-down control.

vascular – plants that have sap-carrying vessels (similar to blood vessels).

vertebrate – an animal of a large group distinguished by the possession of a backbone or spinal column, including mammals, birds, reptiles, amphibians, and fishes.

vision – a broad philosophical statement that describes what the parks should be with regard to future resource conditions and human experiences.

waterbody – collective term used for a lentic "body" of water, such as a lake, pond or marsh.

watershed – an elevated boundary area separating tributaries draining into different river systems.

wilderness – an area set aside by Congress as part of the wilderness preservation system. The intent is to protect lands in their primitive condition with little impact by man. These are unroaded areas where no development is permitted, and certain uses, such as motor vehicles, motorized equipment or motorboats, landing of aircraft, any form of mechanical transport, and landing of aircraft, are prohibited.

wilderness character – essential features of every wilderness, regardless of size, location, agency administration, or any other attribute. These characteristics require that wilderness be *natural* (ecological systems are substantially free from the effects of modern civilization), provide *solitude* (there are outstanding opportunities for solitude or other primitive and unconfined recreation), be *undeveloped* (retain its primeval character and influence, and is essentially without permanent improvement or modern human occupation), and *untrammeled* (essentially unhindered and free from the actions of modern human control or manipulation). Some specific sites within wilderness areas may have their character defined by special ecological, geological, or other features of scientific, educational, scenic, or historical value.

zooplankton – microscopic or barely visible animals that eat algae (i.e., the animal form of plankton). Freshwater zooplankton found in high mountain lakes would include microscopic animals such as protozoans, rotifers, copepods, and cladocerans. Zooplankton are an important component of the lake food web and ecosystem, and are a primary food source for many organisms.

zoospores – a motile, unicellular, flagellate spore. Zoospores can be created by algae, bacteria, and fungi (e.g., chytrid zoospores).

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CHAPTER 1 - PURPOSE AND NEED

INTRODUCTION

This *Restoration of Native Species in High Elevation Aquatic Ecosystems Plan / Final Environmental Impact Statement* (Restoration Plan/FEIS) provides a range of management alternatives for the restoration and conservation of high elevation aquatic ecosystems within Sequoia and Kings Canyon National Parks (SEKI or parks), California. This Restoration Plan/FEIS analyzes the impacts that could result from no action, or implementation of any of three action alternatives.

The National Park Service (NPS) is considering expanding the current high elevation aquatic ecosystem restoration program within SEKI to encompass additional sites and incorporate alternative methods. Thus far, SEKI has restored 15 lakes and ponds and has nearly finished restoring 10 lakes and ponds by eradicating nonnative trout using physical tools (e.g., gill nets and electrofishers). The current methodology of physically removing nonnative fish does not meet goals to restore and conserve aquatic ecosystems on the parks scale. The range of lake types in which physical eradication of self-sustaining nonnative fish populations is possible is limited to less complex habitats: for example, lakes with relatively-short or simple connected streams. To broaden the types of lake systems that can be restored (including whole basins), the NPS is proposing to expand the current program, both in the number and types of waterbodies to be restored and the types of treatment methods to be utilized. The plan evaluates expanding restoration efforts to more complex aquatic ecosystems using both physical-based and alternative methods. The NPS is considering using piscicides (rotenone) in order to restore these ecologically significant habitats.

In SEKI, native fish species were found in the lower elevation reaches of the Kaweah, Kern, and Kings Rivers, typically below 6,000 ft (1,800 m) in elevation (Moyle et al. 1996). The high elevation aquatic ecosystems addressed in this Restoration Plan/FEIS include selected lakes, ponds, streams, and marshes found from approximately 6,000 ft (1,800 m) to 12,000 ft (3,700 m) in elevation, with the majority of sites found above 10,000 ft (3,000 m). All of the proposed restoration sites and virtually all of the waters in the lake basins, which are perched above the high gradient streams, were naturally fishless. These waterbodies occur in historically fishless lake basins and provide habitat for a diverse assemblage of native species that developed over thousands of years in a fishless environment. From 1870 to 1988, nonnative fish [rainbow/golden hybrid trout (*Oncorhynchus mykiss mykiss x aquabonita*), brook trout (*Salvelinus fontinalis*), and brown trout (*Salmo trutta*)] were introduced into many heretofore fishless waterbodies throughout SEKI. Surveys conducted from 1997 to 2002 (Knapp R., unpublished data) determined that self-sustaining nonnative trout populations had become established in approximately 575 lakes, ponds, and marshes, plus connecting streams, and nearly all streams that drain these sites from high to low elevations.

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.

Although SEKI has shown that fish eradication is feasible and beneficial for native species (NPS 2015A), the use of physical methods is only feasible in relatively simple (non-complex) habitat: generally, lakes with few and/or small connecting stream sections totaling no more than 2 mi (3.2 km) in length and/or having no individual sections more than 1 mi (1.6 km) in length. Some of the remaining potential restoration areas in SEKI that have value for addressing ecosystem recovery (including whole basins) contain much more complex habitat involving large lakes or clusters of many lakes, with many and/or large connecting streams, generally totaling more than 2 mi (3.2 km) and/or having individual sections more than 1 mi (1.6 km). Many of these areas also contain large, deep and/or cold lakes that have the best capacity to resist drier and warmer conditions expected in the future due to global climate change. Restoring large areas is thus critical for native species to continue to have access to high-quality habitat once smaller waterbodies dry up or become too warm. Nonnative fish eradication from many larger ecosystems with complex habitat has been determined infeasible using physical methods alone. Therefore, this Restoration Plan/FEIS considers the use of alternative methods for restoring larger areas, which are more resistant to ecological stressors, such as long-term drought and warming.

The overall goal of this Restoration Plan/FEIS is to restore clusters of waterbodies to their naturally fishless state in strategic locations across SEKI to create high elevation ecosystems with more favorable habitat conditions for the persistence of native species and ecosystem processes. The Restoration Plan/EIS presents a range of alternative management actions to restore and conserve native species diversity and ecological function to selected high elevation aquatic ecosystems in SEKI that have been disturbed by human activities, particularly the stocking of nonnative trout. The Restoration Plan/FEIS describes the no action alternative and three action alternatives that are being considered during this planning effort, and presents an analysis of the impacts of the alternatives on the natural, cultural, and physical resources in SEKI. The alternatives represent a range of reasonable and feasible options for addressing the goals and objectives of this plan, and the issues and concerns raised by parks staff, other government agencies, and members of the public during the plan’s scoping process and publice comment period. Upon conclusion of this Restoration Plan/FEIS, one of the four alternatives would become the *Restoration of Native Species in High Elevation Aquatic Ecosystems Plan* and guide future restoration management actions for a period of up to 35 years, depending on the alternative selected.

The management strategies included in this Restoration Plan/FEIS are intended to be adaptive and dynamic, allowing for the incorporation of new scientific information over time to best meet the objectives of the aquatic ecosystem restoration program. Therefore, this plan calls for monitoring, assessment, and regular programmatic reviews. During implementation, the effectiveness of this plan would be reviewed at least once every 5 to 10 years to evaluate new species information, scientific findings, habitat information, and restoration and monitoring results. Following each review, the plan would be revised if necessary to address emerging issues and incorporate new information into the management strategies. Additional public involvement would occur as appropriate.

The development and public review of this Restoration Plan/FEIS is consistent with the *National Environmental Policy Act of 1969, as amended* (NEPA), the NEPA regulations promulgated by the Council on Envirnmental Quality and the Department of the Interior, NPS *Management Policies 2006* (NPS 2006A), and the NPS NEPA handbook. To facilitate the California water quality permitting process in compliance with the Clean Water Act, and as recommended by the California Water Quality Control Board, this plan is also consistent with the *California Environmental Quality Act* (CEQA; California Public Resources Code, Section 21000 et seq.).

PURPOSE AND NEED FOR THE PLAN

Purpose of the Plan

The purpose of this Restoration Plan/FEIS is to guide management actions by the NPS to restore and conserve the native species diversity and ecological function of selected high elevation aquatic ecosystems that have been adversely impacted by human activities including the introduction of nonnative fish, and to increase the resistance and resilience of these species and ecosystems to human-induced environmental modifications, such as disease and unprecendented climate change. The Restoration Plan/FEIS would be implemented over a period of 20 to 35 years, depending on the alternative selected, with an evaluation of management effectiveness scheduled every 5 to 10 years.

Need for the Plan

This Restoration Plan/FEIS is needed to provide long-term management direction to restore and conserve SEKI's high elevation aquatic species and ecosystems. 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 (NPS 2006A) and is among the desired conditions established in SEKI's *Final General Management Plan/Final Environmental Impact Statement* (NPS 2007).

Action is needed at this time:

- because nonnative fish have severely reduced native biological diversity and disrupted ecological function;
- to prevent the extirpation of two species of mountain yellow-legged frogs (*Rana muscosa* and *Rana sierrae*, collectively referred to as MYLFs) from the parks and to restore MYLF populations to many locations in the parks where they have been extirpated;
- to further the NPS's mission and policy directives to conserve native animals, plants, and processes found in SEKI's aquatic ecosystems;
- because large scale restoration of more complex habitat (areas containing large lakes or clusters of many lakes with many and/or large connecting stream sections) is critical for native species and ecosystem recovery;
- to increase the resistance and resilience of native high elevation aquatic species and ecosystems to human-induced environmental change; and
- to enhance and preserve the natural quality of wilderness character.

NPS *Management Policies 2006* (NPS 2006A) directs parks to implement feasible management actions to respond to resource threats. As the parks' managers have gained a better understanding of high elevation aquatic ecosystems and potential threats to their integrity, it was determined that a comprehensive plan is needed to evaluate and respond to these threats. Some of these threats are outside the direct control of park management (e.g., global climate change, air pollution, and disease). However, other threats, such as the presence of nonnative trout, are the result of human actions in SEKI and are within the ability of the NPS to mitigate. This Restoration Plan/FEIS is needed to provide guidance for restoration and conservation of native species and high elevation aquatic ecosystems in SEKI, and to increase the resistance and resilience of these species and ecosystems to human-induced environmental change.

Many studies conducted in SEKI and elsewhere in the Sierra Nevada have analyzed the effects that nonnative trout have on native species and ecosystems (see appendix C; and the "Impacts of Nonnative Fish on High Elevation Aquatic Ecosystems" section, under "Background"). These studies consistently found 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 alter, deplete, or eliminate populations of these animals from naturally fishless habitats. The animals that are consumed by nonnative trout occupy the middle of native food webs, functioning as both prey and predators. Their reductions as prey result in less food being available to native predators, such as snakes, birds, and mammals, in turn altering the distribution and abundance of these animals. Their reductions as predators affect the roles of herbivores and detritivores and associated nutrient cycling. When extirpations occur, all associated ecosystem functions associated with the species are lost. 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 a large portion of the parks' high elevations. NPS restoration actions to date have demonstrated that eradication of nonnative trout from individual waterbodies in SEKI can reverse these impacts in certain lake types (NPS 2011A). The parks' current restoration program does not include the tools necessary to restore a more diverse set of habitats on larger scales. This Restoration Plan/FEIS evaluates additional tools for conducting high elevation aquatic ecosystems restoration at the landscape scale in SEKI.

Two species that are integral components of SEKI's high elevation aquatic ecosystems are the MYLFs. Formerly abundant, MYLFs are today among the world's most endangered amphibians: over 92% of their populations in the Sierra Nevada have disappeared, and most of the remaining populations are much smaller and more isolated than they were historically (Vredenburg et al. 2007). Extensive research has identified two primary factors for this decline. The first factor is the introduction of nonnative trout. Nonnative trout have several direct effects on MYLFs, including predation, competition for food, restriction of breeding to marginal habitat, and fragmentation of remaining populations (Bradford et al. 1993, Knapp and Matthews 2000, Vredenburg 2004, Finlay and Vredenburg 2007). The second factor is the recent spread of chytridiomycosis, a disease caused by amphibian chytrid fungus (*Batrachochytrium dendrobatidis*), which has infected and imperiled most remaining MYLF populations (Rachowicz et al. 2006, Vredenburg et al. 2010A). While in many cases, amphibian chytrid fungus has caused complete extirpation of MYLF populations, some populations have persisted. This implies that some MYLF populations contain enough genetic diversity (which generally increases with population size) that a subset of individuals may persist, despite the presence of amphibian chytrid fungus. These resilient MYLFs are able to reproduce and allow the possibility for gradual post-die-off population expansion. However, a MYLF population in a fish-containing basin that is naïve to amphibian chytrid fungus is often very small, and may lack the genetic diversity to persist following an outbreak of amphibian chytrid fungus (Allentoft and O'Brien 2010, Frankham et al. 2010, Schoville et al. 2011).

A third emerging factor is global climate change, which has begun to dry up smaller, shallower ponds in SEKI (Lacan et al. 2008). Ponds have become important habitat for MYLFs because, in basins where nonnative trout occur, fish occupy most of the larger lakes, which are more resistant to climate change. This has restricted many MYLF populations to smaller waterbodies that are more vulnerable to drought and warming (Lacan et al. 2008, Ryan et al. 2014).

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), frogs 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). Therefore, this Restoration Plan/FEIS is needed not only to help prevent MYLFs from going extinct, but also to restore healthy native high elevation ecosystems in SEKI.

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 the parks' landscape with a full complement of native biodiversity is a key component of the natural quality of wilderness character. The natural quality of wilderness character in SEKI is being compromised by the large decline of MYLF populations in the parks. Preventing the extirpation of MYLFs from the parks and restoring these species to aquatic environments that they historically inhabited would enhance and preserve the natural quality of wilderness character. This Restoration Plan/FEIS is needed to help achieve the parks' goals of enhancing and preserving the natural quality of wilderness character (NPS 2007, NPS 2015B).

Objectives of the Restoration Program

Objectives are more specific statements of purpose that describe the desired outcomes a management alternative must largely achieve for this proposed aquatic ecosystem restoration effort to be considered a success. Objectives directly address the problems and issues presented in the purpose and need, and when possible, are linked to executive orders, laws, policies, park plans, and other guidance. As the ability to achieve objectives is part of what defines an alternative as reasonable, objectives also provide critical boundaries for action.

The following management objectives were developed for this Restoration Plan/FEIS based on the purpose and need for the plan, are in accordance with the executive orders, laws, policies, and plans that guide management of natural resources in national parks, and are summarized below.

A) Restore and conserve the natural abundance, distribution, and function of native species, populations and communities within selected high elevation aquatic ecosystems, by:

- implementing management actions to create more favorable conditions for these populations to persist and be more resilient to human-induced changes to environmental conditions; and
- restoring habitat to its historically fishless condition at the parks scale, including the eradication of fish from up to 85 (15%) of 550 nonnative fish-containing lakes, ponds, and marshes, approximately 31 mi of streams, and connected fish-containing habitat as necessary.

B) Develop a long-term conservation strategy for both species of MYLFs to ensure the self-sustaining, long-term viability and evolution of MYLF populations in perpetuity within portions of their present and historic geographic range within the parks, and to maintain the genetic and ecological diversity of these species. Specific objectives related to this strategy include:

- reverse widespread loss of the ecological function formerly provided by MYLFs and maintain the viability of existing MYLF populations throughout the range of both species within the parks;
- restore selected habitat and expand existing MYLF populations;
- re-establish MYLFs in selected basins where populations were historically present, but are now absent; and
- collaborate with partner agencies and organizations to exchange information, enhance use of available resources, and strategically restore and conserve MYLFs in the Sierra Nevada.

C) Develop a list of research priorities to better understand aquatic ecosystem functional integrity, biodiversity and capacity to adapt to unprecedented rates of human-induced change.

D) Use results from restoration efforts and new data from research studies to refine program methodologies over time and mitigate impacts that have the potential to occur during restoration.

E) Restore and protect natural processes in wilderness, using an appropriate range of management actions derived from careful analyses of potential effects to wilderness character and resources.

F) Provide an appropriate range of visitor experiences and recreational opportunities at wilderness lakes and streams concurrent with reducing the degradations that have occurred to the biological integrity of high elevation aquatic ecosystems.

The objectives for this Restoration Plan/FEIS are grounded in a series of laws commonly known as the National Park Service Organic Act of 1916, the General Authorities Act of 1970, and the Redwood Amendments of 1978 that provide overall management direction for units of the National Park System. 54 U.S.C. 100101 *et. seq.* These interrelated authorities express the fundamental purpose of the National Park System, which begins with the mandate to conserve park resources and values and also includes the mandate to provide for visitor enjoyment of these resources and values. The mandate to conserve park resources and values is complemented by a statutory prohibition on the impairment of park resources and values.

To avoid impairment, NPS *Management Policies 2006* direct park managers to seek ways to avoid and minimize adverse impacts on park resources and values to the greatest extent practicable (NPS 2006A). NPS *Management Policies 2006* states that the NPS will seek to return natural systems impacted by human disturbances, including the introduction of exotic species and the disruption of natural processes, to the natural conditions and processes characteristic of the ecological zone in which the damaged resources are situated. The NPS will use the best available technology, within available resources, to restore the biological and physical components of these systems, accelerating both their recovery and the recovery of landscape and biological community structure and function. Efforts may include the removal of exotic species and the restoration of native plants and animals (Section 4.1.5). This section of *Management Policies 2006* informed the development of objectives A and B in this Restoration Plan/FEIS.

The policies also recognize that resource conservation takes precedence over visitor recreation. The policies state “Congress, recognizing that the enjoyment by future generations of the national parks can be ensured only if the superb quality of park resources and values is left unimpaired, has provided that when there is a conflict between conserving resources and values and providing for enjoyment of them, conservation is to be predominant” (Section 1.4.3). This section of *Management Policies 2006* informed the development of objectives A, B, and F in this Restoration Plan/FEIS.

The plan was also developed in keeping with the *National Park Omnibus Management Act of 1998* (54 U.S.C. 5931; P.L. 105-391) (NPOMA). In relevant part, the purpose of NPOMA is, “to enhance management and protection of national park resources by providing clear authority and direction for the conduct of scientific study in the National Park System and to use the information gathered for management purposes; to ensure appropriate documentation of resource conditions in the National Park System.” This legislation informed the development of objectives B, C, and D in this Restoration Plan/FEIS.

The objectives for this Restoration Plan/FEIS are closely tied to the *Endangered Species Act of 1973*, as amended (ESA; 16 USC § 1531 et seq.), the *California Endangered Species Act* (CESA; California Fish and Game Code, Sections 2050 et seq.), the NPS *Management Policies 2006*, SEKI’s GMP (General Management Plan; NPS 2007), and the multi-agency range-wide conservation planning efforts that have occurred or are occurring as a result of the MYLFs’ dramatic decline. Section 7(a)(1) of the ESA directs federal agencies to utilize their existing authorities to further the conservation of listed species. Section 7(a)(2) of the ESA requires all federal agencies to consult with the U.S. Fish and Wildlife Service (FWS) to ensure that any action authorized, funded, or carried out by an agency does not jeopardize the continued existence of listed or proposed species or designated or proposed critical habitat. The CESA protects and preserves all native species and their habitats that are threatened with extinction, and those experiencing a significant decline which, if not halted, would lead to a threatened or endangered designation. These laws and policies informed the development of objectives B and D in this Restoration Plan/FEIS.

Under NPS *Management Policies 2006*, the NPS is required to protect and to strive to recover all native species that are listed under the ESA and to conduct actions and allocate funding to address endangered, threatened, proposed, and candidate species. These actions include control of nonnative species and reestablishment of extirpated populations. State-listed species are to be treated in as similar a manner as possible (Section 4.4.2.3). These policies also direct NPS to cooperate with other agencies and participate in range-wide recovery planning processes. This section of *Management Policies 2006* informed the development of objectives A and B in this Restoration Plan/FEIS.

NPS *Management Policies 2006* (NPS 2006A) 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). Exotic species, such as nonnative trout, are “those species that occupy…park lands directly or indirectly as the result of deliberate or accidental human activities. This section of *Management Policies 2006* informed the development of objectives A, B, and D in this Restoration Plan/FEIS.

Taxonomic studies conducted by Vredenburg et al. (2007) indicated that the MYLF should be split into two species, *R. muscosa* and *R. sierrae*. In 2014, the FWS officially adopted this taxonomic distinction when they listed the Sierra Nevada yellow-legged frog (*R. sierrae*) and the northern distinct population segment (DPS) of the mountain yellow-legged frog (*R. muscosa*) as endangered (FWS 2014A). MYLFs in the Sierra Nevada are thus now recognized as (1) the Sierra Nevada yellow-legged frog (*R. sierrae*) north of the South Fork of the Kings River watershed and (2) the northern DPS of the mountain yellow-legged frog (*R. muscosa*) in the South Fork of the Kings River and Kern River watersheds. The FWS concluded that declines in the distribution and abundance of the species were largely attributed to the introduction and subsequent predation of introduced nonnative fish. The small size and isolation of remaining populations and habitat fragmentation as a result of nonnative fish introductions and a disease epidemic has made remaining populations vulnerable to extinction from random events such as disease outbreaks and potential impacts from climate change.

In response to the severe decline to MYLF populations, the U.S Forest Service (USFS) led a multi-agency working group (that included NPS scientists) to develop a *Sierra Nevada Mountain Yellow-legged Frog Conservation Assessment* (Brown et al. 2014). The Conservation Assessment is a tool to guide future conservation strategy and recovery planning for the Sierra Nevada MYLFs. 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 Conservation Assessment identified restoring fishless habitat and developing a translocation study as key conservation options for recovering the species. The FWS, NPS, USFS, and CDFW are currently collaborating on the development of the *Mountain Yellow-legged Frog Complex Conservation Strategy* (FWS *in preparation*). 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 drafted that eradicating introduced fish and developing methods for successful translocations are the primary tools available for recovering MYLFs.

The CDFW recommended listing *R. muscosa* as endangered and *R. sierrae* as threatened under the CESA following an extensive review of the status and threats to the two species (CDFW 2011). CDFW has been actively engaged in conservation of the species for over 10 years and they have documented, along with other agencies, including the NPS, precipitous range-wide declines. In their status review, CDFW concluded that the introduction of nonnative fishes and disease are the principle drivers of decline. Their management recommendations include continuing to remove nonnative trout from targeted waterbodies to benefit resident MYLF populations and to provide fish-free habitat for future translocations. They also recommended special focus on research directed at reintroducing MYLFs in an environment where amphibian chytrid fungus is prevalent. The California Fish and Game Commission adopted the (CDFW) findings on the petition to list MYLFs under the *CESA* on Feb 2, 2012, voting unanimously to list *Rana muscosa* as endangered and *Rana sierrae* as threatened. The listings are now final and have been adopted in Title 14 CCR §670.5.

NPS *Management Policies 2006* also addresses nonnative species and direct parks to manage nonnative species "up to and including eradication if (1) control is prudent and feasible, and (2) the exotic species interferes with natural processes…, native species or natural habitats, or disrupts the genetic integrity of native species" (Section 4.4.4.2). High priority is given to managing exotic species which have, or potentially could have, a substantial impact on park resources, and that can reasonably be expected to be successfully controlled. Exotic species are also commonly referred to as nonnative, alien, or invasive species" (Section 4.4.1.3). The substantial impacts to native ecosystems from nonnative trout (Bradford et al. 1998, Matthews et al. 2002, Knapp and Sarnelle 2008, Herbst et al. 2009, Pope et al. 2008, Epanchin et al. 2010) and the effectiveness of fish eradication as a restoration tool are well established by science (Knapp et al. 2007). SEKI's GMP (NPS 2007) calls for the management of populations of exotic animal species, up to and including eradication, whenever exotic species threaten park resources and wherever control is prudent and feasible. Thus, the objectives of this Restoration Plan/FEIS would meet the direction provided by NPS policy and the GMP by restoring two native species and their associated ecosystems through the eradication of nonnative fish. These sections of *Management Policies 2006* informed the development of objectives A and D in this Restoration Plan/FEIS.

Section 4.2.1 provides guidance related to research and monitoring. The NPS will identify, acquire and interpret needed inventory, monitoring and research, including applicable traditional knowledge, to obtain information and data that will help the parks' managers accomplish the parks' management objectives provided for in law and planning documents; define, assemble and synthesize comprehensive baseline inventory data describing the natural resources under NPS stewardship, and identify the processes that influence those resources; use qualitative and quantitative techniques to monitor key aspects of resources and processes at regular intervals; analyze the resulting information to detect or predict changes that may require management intervention and provide reference points for comparison with other environments and time frames; and use the resulting information to maintain—and where necessary restore—the integrity of natural systems. This section of *Management Policies 2006* informed the development of objectives A, B, C, and D in this Restoration Plan/FEIS.

The NPS may support studies to (among other things) provide a sound basis for policy, guidelines and management actions; develop effective strategies, methods and technologies to restore disturbed resources, and predict, avoid or minimize adverse impacts on natural and cultural resources and on visitors and related activities. This informed development of objective D in this Restoration Plan/FEIS.

NPS *Management Policies 2006* provide that whenever possible, natural processes will be relied upon to maintain native plant and animal species and influence natural fluctuations in populations of these species. However, the NPS may intervene to manage individuals or populations of native species only when (1) 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; and (2) at least one of the following conditions exists:

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 or the creation of highly productive habitat through agriculture or urban landscapes) and it is not possible to mitigate the effects of the human influences;
- to protect specific cultural resources of parks;
- to accommodate intensive development in portions of parks appropriate for and dedicated to such development;
- to protect rare, threatened or endangered species;
- to protect human health as advised by the U.S. Public Health Service (which includes the Centers for Disease Control and the NPS public health program);
- to protect property when it is not possible to change the pattern of human activities; or
- to maintain human safety when it is not possible to change the pattern of human activities.

Or,

The removal of individuals or parts thereof

- is part of an NPS research project described in an approved management plan, or is part of research being conducted by others who have been issued a scientific research and collecting permit;
- is done to provide plants or animals for restoring native populations in parks or cooperating areas without diminishing the viability of the park populations from which the individuals are taken; or
- meets specific park management objectives (NPS Management Policies Section 4.4.2).

Section 4.4.2.2 of *Management Policies 2006* states that the NPS will strive to restore extirpated native plant and animal species to parks whenever all of the following criteria are met:

- Adequate habitat to support the species either exists or can reasonably be restored in the park and if necessary also on adjacent public lands and waters; once a natural population level is achieved, the population can be self-perpetuating.
- The species does not, based on an effective management plan, pose a serious threat to the safety of people in parks, park resources, or persons or property within or outside park boundaries.
- The genetic type used in restoration most nearly approximates the extirpated genetic type.
- The species disappeared or was substantially diminished as a direct or indirect result of human-induced change to the species population or to the ecosystem.
- Potential impacts upon park management and use have been carefully considered.

With regards to sensitive species, the NPS will inventory, monitor and manage state and locally listed species in a manner similar to its treatment of federally listed species to the greatest extent possible. In addition, the NPS will inventory other native species that are of special management concern to parks (such as rare, declining, sensitive or unique species and their habitats) and will manage them to maintain their natural distribution and abundance (*Management Policies 2006,* Section 4.4.2.3). These sections of *Management Policies 2006* informed the development of objectives A, B, C, and D in this Restoration Plan/FEIS.

Management Policies 2006 further states that exotic species will not be allowed to displace native species if displacement can be prevented (Section 4.4.4). 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;
- disrupts the genetic integrity of native species;
- disrupts the accurate presentation of a cultural landscape, or damages cultural resources;
- significantly hampers the management of park or adjacent lands;
- poses a public health hazard as advised by the U.S. Public Health Service (which includes the Centers for Disease Control and the NPS public health program); or
- creates a hazard to public safety.

Programs to manage exotic species will be designed to avoid causing significant damage to native species, natural ecological communities, natural ecological processes, cultural resources and human health and safety (*Management Policies 2006*, Section 4.4.4.2). Per *Management Policies 2006*, this plan has been written to ensure that the removal of exotic species will not cause unacceptable damage (*Management Policies 2006*, Section 4.4.2.1). These sections of *Management Policies 2006* informed the development of objectives A and D in this Restoration Plan/FEIS.

In terms of management within wilderness, NPS *Management Policies 2006* notes 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). This guidance from NPS *Management Policies 2006* informed the development of objectives A, B, and D in this Restoration Plan/FEIS, which would enable SEKI to help prevent the MYLFs from being extirpated in the parks.

The vast majority of MYLF habitat in SEKI is in designated wilderness or potential wilderness additions and is managed in accordance with the *Wilderness Act of 1964* (16 USC § 1131 et seq., P.L. 88-577). The Wilderness Act seeks to "secure for the American people of present and future generations the benefits of an enduring resource of wilderness." (16 U.S.C. § 1131(a)). Federal agencies are required to administer designated wilderness "for the use and enjoyment of the American people in such manner as will leave them unimpaired for future use as wilderness, and so as to provide for the protection of these areas, the preservation of their wilderness character […]." (16 U.S.C. § 1131(c)). Under Section 4(c) of the Act, certain uses are prohibited in wilderness. The Act states that "[….] except as necessary to meet minimum requirements for the administration of the area for the purpose of this Act [….], there shall be [….] no landing of aircraft, [….] and no structure or installation within any such area."

SEKI's original wilderness designation occurred under the *California Wilderness Act of 1984* (16 USC § 1131 et seq., 1131, P.L. 98-425, 98 Stat. 1619). Additional acreage was designated as wilderness by the *Omnibus Public Land Management Act of 2009* (H.R. 146). Total designated wilderness for the parks is approximately 807,962 ac (326,970 ha) – approximately 93.3% of the parks' total acreage. In addition, there is approximately 30,000 ac (12,100 ha) of proposed wilderness that is managed as wilderness in accordance with NPS policy. 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. Indeed, the continuance or restoration of native wildlife populations dependent on natural habitats often constitutes one of the prime reasons for designating wilderness, and is one of the 'conservation' purposes for which wilderness is to be managed pursuant to section 4(b) of the Wilderness Act." Hence, the objectives of this Restoration Plan/FEIS are founded in the intent of the 1984 Act and meet the purpose of the Wilderness Act by enhancing and preserving the natural qualitiy of wilderness character. This legislation informed the development of objectives A, B, D, and E in this Restoration Plan/FEIS.

Per NPS *Management Policies 2006*, the NPS will manage wilderness areas for the use and enjoyment of the American people in such a manner as will leave them unimpaired for future use and enjoyment as wilderness. Management will include the protection of these areas, the preservation of their wilderness character, and the gathering and dissemination of information regarding their use and enjoyment as wilderness. The purpose of wilderness in the national parks includes the preservation of wilderness character and wilderness resources in an unimpaired condition and, in accordance with the Wilderness Act, wilderness areas shall be devoted to the public purposes of recreational, scenic, scientific, educational, conservation and historical use. The NPS recognizes that without natural resources, especially indigenous and endemic species, a wilderness experience would not be possible. Natural resources are critical, defining elements of the wilderness resource, but they need to be managed within the context of the whole ecosystem (*Management Policies 2006*, Section 6.3.7).

NPS *Management Policies 2006* states that natural resources management in wilderness will include and be guided by a coordinated program of scientific inventory, monitoring and research. The principle of non-degradation will be applied to wilderness management, and each wilderness area’s condition will be measured and assessed against its own unimpaired standard. Natural processes will be allowed, insofar as possible, to shape and control wilderness ecosystems. Management should seek to sustain the natural distribution, numbers, population composition and interaction of indigenous species (Section 6.3.7). This section of *Management Policies 2006* informed the development of objectives A, B, C, D, and E in this Restoration Plan/FEIS.

Visitor use is addressed in *Management Policies 2006* Section 8.2. The enjoyment of park resources and values by the people of the United States is part of the fundamental purpose of all parks. The NPS is committed to providing appropriate, high-quality opportunities for visitors to enjoy the parks. To provide for enjoyment of the parks, the NPS will encourage visitor activities that are appropriate to the purpose for which the park was established; and are inspirational, educational or healthful and otherwise appropriate to the park environment; and will foster an understanding of and appreciation for park resources and values, or will promote enjoyment through a direct association with, interaction with or relation to park resources; and can be sustained without causing unacceptable impacts to park resources or values. This section of *Management Policies 2006* informed the development of objectives A and F in this Restoration Plan/FEIS.

Any work proposed within a wilderness area must go through a documented process to determine whether the proposed management actions would be appropriate or necessary for administration of the area as wilderness; and, whether the techniques and types of equipment or activities to be used ensure that impacts on wilderness resources and character are minimized. This documentation is known as a Minimum Requirement Analysis (MRA). The MRA for this proposed project is located in appendix A. All proposed work would comply with wilderness requirements and wilderness values.

Project Site Location
Sequoia and Kings Canyon National Parks (SEKI) protect 865,964 ac (350,443 ha) along the western slope of the Sierra Nevada mountain range in east-central California (see Figure 1, in the Executive Summary, page v). Sequoia National Park, established in 1890, and Kings Canyon National Park, established in 1940, are administered as a single unit that rises from the low western foothills at 1,370 ft (418 m) to the summit of Mount Whitney at approximately 14,494 ft (4,418 m). These two parks make up the geographical area for this Restoration Plan/FEIS.

Two wilderness areas are located within SEKI, including the Sequoia-Kings Canyon Wilderness and John Krebs Wilderness. The entirety of SEKI is within Tulare and Fresno counties. Drivable access is by California State Routes 180 and 198, which within SEKI is known as the Generals Highway. Many other public lands surround SEKI, including Sequoia National Forest to the south and southwest, Sierra National Forest to the north and northwest, and Inyo National Forest to the east. These national forests include several areas with federal designations that adjoin much of the SEKI boundary, including the John Muir Wilderness, Golden Trout Wilderness, Monarch Wilderness, Jennie Lakes Wilderness, and Giant Sequoia National Monument. Stocking of nonnative fish has occurred in many lakes within these national forest boundaries since the late 1800s and continues today.

Although the geographical area for this Restoration Plan/FEIS includes all of SEKI, the focus of this document is the aquatic habitat located from approximately 6,000 ft (1,800 m) to 12,000 ft (3,700 m) in elevation. In these areas, SEKI contains approximately 3,500 high elevation lakes, ponds, and marshes (waterbodies) (Knapp R., unpublished data), and an estimated more than 1,000 mi (1,600 km) of rivers and streams (NPS 2005), including portions of the headwaters of the Kaweah, Kern, Kings, San Joaquin and Tule Rivers. The majority of the 3,500 waterbodies – approximately 2,500 - are ponds (< 2.5 ac/1 ha), many of which are very small, only holding snowmelt water during early summer and drying completely during late summer (~1,000 are < 0.25 ac/0.1 ha). Approximately 1,000 of the 3,500 waterbodies are lakes (2.5 ac/1 ha or larger), all of which currently hold water year-round that can sustain native species such as MYLFs. In addition, many of the lakes are large (~600 are 5 ac/2 ha or larger), which can provide native species with reliable habitats that will buffer drying and warming expected over time due to climate change.

Although all of SEKI's high-elevation waterbodies were naturally fishless, surveys conducted from 1997 to 2002 determined that self-sustaining nonnative fish populations had become established in approximately 575 lakes, pond and marshes (Knapp R., unpublished data), plus connecting streams, and nearly all streams that drain these sites from high to low elevation. A total of 25 waterbodies that contained nonnative fish were previously approved for fish eradication (NPS 2001, 2009A), and thus 550 waterbodies that contain nonnative fish are potential candidates for additional fish eradication. From these 550 potential candidates, 85 waterbodies (31 lakes, 49 ponds, and 5 marshes), or 15% of the remaining waterbodies that contain nonnative fish, were selected for analysis in this Restoration Plan/FEIS (see chapter 2 and appendix B) using the basin selection criteria presented in Table 1 and Table 7.

BACKGROUND

Past Aquatic Ecosystem Management in High Elevation Waterbodies

Historical management of aquatic resources in SEKI's high elevations primarily consisted of (1) stocking nonnative fish into naturally fishless waterbodies (from 1870 to 1988) and (2) researching the ecological effects of nonnative fish on naturally fishless aquatic ecosystems (from the 1970s to present).

Historically, SEKI's high elevation waterbodies were inhabited by a diverse assemblage of aquatic species that developed over thousands of years in a fishless environment. This fishless environment was due to extensive Pleistocene glaciation that created the waterbodies, and steep topography that contained many barriers to fish passage (Moyle et al. 1996). As a result, fish were naturally restricted in distribution to low or middle elevation streams depending on the watershed (Moyle et al. 1996).

The first recorded stocking of nonnative trout into SEKI's fishless high elevation waterbodies occurred in 1870 and unrecorded stockings may have occurred as early as the 1850s (Christenson 1977). Before Sequoia National Park was established in 1890, nonnative fish stocking into high elevation waterbodies was largely conducted by various sporting groups (Knapp 1996). After Sequoia National Park was established, U.S. Army staff managed the new park lands and conducted extensive fish stocking (Christenson 1977). In both cases, easily accessed waterbodies were stocked with fish using packstock.

After the NPS was created in 1916, NPS staff continued to conduct fish stocking in park waterbodies, and the California Fish and Game Commission began coordinating these efforts. By the 1940s, fish stocking in park waterbodies was almost entirely managed by the CDFW (Knapp 1996), with permission from the NPS. Under CDFW management, nonnative fish were systematically stocked using aircraft to plant fish in remote lakes. From the 1940s to the 1970s, most large waterbodies in SEKI were stocked at least once; many were stocked repeatedly with nonnative fish.

In the 1960s, the NPS began to apply a Servicewide policy of science-based management. The "Leopold Report" (Leopold et al. 1963) assessed various NPS resources management policies and among many findings concluded that (1) fish stocking into naturally fishless habitat was not congruent with NPS management policies and (2) indiscriminate stocking of nonnative fish into naturally fishless waterbodies may be causing negative ecological effects. The report recommended that the NPS should reevaluate its fish stocking policy and investigate whether nonnative fish stocking was impacting native species.

In the 1970s, SEKI began phasing out nonnative fish stocking while conducting a study of nonnative trout in 137 SEKI lakes (Zardus et al. 1977) to determine how those populations might respond to an absence of stocking. The study found that fish in 97 (72%) of the 137 lakes were likely able to sustain their populations in the absence of stocking. The study also recorded observations of other biota, reporting MYLFs swimming in open water in two (1.5%) of the 137 lakes, and stating: "In lakes with large populations of fish, tadpoles are observed only in shallow or protected waterbodies, or are not present at all." In addition, in 1975 the NPS adopted a policy in which naturally fishless waterbodies will no longer be stocked with fish (NPS 1975). As a result, the NPS proposed to terminate the authorization for CDFW to continue stocking nonnative fish in SEKI lakes. Instead, a compromise was reached in which CDFW was allowed to continue stocking fish in no more than seven lakes per year in SEKI, intermittently selected from a total of 16 high use lakes. This practice continued until 1988 when the NPS terminated all fish stocking in SEKI lakes. Although stocking no longer occurs in SEKI, nonnative fish had established self-sustaining populations in approximately 575 waterbodies (Knapp R., unpublished data) and in hundreds of miles of stream.

In the 1980s and 1990s, while additional studies were investigating landscape-scale effects of nonnative fish introductions in SEKI and the high Sierra Nevada (Bradford 1989, Bradford et al. 1993, 1998), researchers and NPS staff observed that amphibians, particularly MYLFs, appeared to be declining even in fishless habitats (Graber D., pers. comm. 2012). Several studies ensued to quantify the MYLF decline and attempted to determine its causal factors. The primary conclusions from these studies were that (1) lake acidity levels were not elevated and thus did not appear to be a contributing factor to MYLF decline (Bradford et al. 1994A), and (2) MYLFs were much less likely to occur in lakes with nonnative fish versus fishless lakes (Bradford et al. 1994B; Knapp and Matthews 2000). To further investigate the effects of nonnative fish, researchers studied the response of MYLFs and other native species (e.g., aquatic invertebrates and zooplankton) when nonnative fish disappeared from historically fishless lakes due to stocking termination or experimental eradication. Results showed that native species quickly recovered toward pre-disturbance levels following the return of lakes to a fishless condition (Knapp et al. 2001, Vredenburg 2004, Knapp et al. 2005, 2007).

Impacts of Nonnative Fish on High Elevation Aquatic Ecosystems
Nonnative fish have been widely introduced to naturally fishless, mountain ecosystems throughout western North America, commonly resulting in negative ecological effects to these systems (Anderson 1971, Bahls 1992, Knapp 1996). In the Sierra Nevada, many studies have shown that nonnative fish have

negatively impacted entire food webs, including native fish, amphibians, aquatic invertebrates, zooplankton and birds (appendix C).

Nonnative fish impact native fish in low-to-mid elevation Sierran streams through hybridization, predation and competition (Moyle 2002). Because nonnative fish have been introduced to all of the Sierran streams containing native fish, the entire native fish assemblage has declined, including several subspecies of trout and several non-trout species. Some of these fish have declined throughout their range and the following have been given protected status by the FWS. Listed as threatened under the Endangered Species Act include the Little Kern golden trout (*Oncorhynchus mykiss whitei*; FWS 1978), Paiute cutthroat trout (*Oncorhynchus clarki seleneris*; FWS 1975) and Lahontan cutthroat trout (*Oncorhynchus clarki henshawi*; FWS 1975). The California golden trout (*Oncorhynchus mykiss aguabonita*) was petitioned for listing but FWS determined that this listing was not warranted at this time (FWS 2002, FWS 2011), and the pure form of Kern River rainbow trout (*Oncorhynchus mykiss gilberti*) has become extremely rare (Erickson et al. 2010).

Nonnative fish directly impact native amphibians by preying on eggs, tadpoles and frogs and competing with frogs for food, thereby reducing or eliminating reproduction (Vredenburg 2004). Nonnative fish typically cause large reductions in distribution and abundance of local MYLF populations (Knapp et al. 2001), ultimately resulting in extirpation in many locations (Bradford et al. 1994B; Knapp 1996, Knapp and Matthews 2000, Knapp 2005A). In turn, the presence of nonnative fish in lakes and streams across SEKI's landscape has fragmented the remaining MYLF populations and drastically reduced their ability to re-establish populations that go extinct (Bradford et al. 1993). The remaining isolated frog populations are thus at much greater risk for extirpation (Lacan et al. 2008). The widespread introduction of nonnative fish is a major factor in the disappearance of MYLF populations from approximately 92% of historic localities in the Sierra Nevada (Vredenburg et al. 2007). Due to this steep decline, in 2003, the FWS listed the Sierra Nevada population of MYLFs as a federal candidate species under the Endangered Species Act (FWS 2003).

Nonnative fish indirectly impact native predators such as the mountain garter snake (*Thamnophis elegans elegans*), which primarily preys on amphibians including MYLFs. These snakes are now less common at fish-containing versus fishless lakes in the high Sierra, likely because amphibians are rarely available as food at fish-containing lakes (Matthews et al. 2002). In addition, nonnative fish directly impact large aquatic invertebrates (Bradford et al. 1998, Knapp et al. 2001) and zooplankton (Stoddard 1987, Knapp et al. 2001) by severely reducing or eliminating them in lakes, and thus indirectly impact wildlife that rely on these organisms for food. This causes trophic cascades in aquatic food webs that extend into terrestrial environments (Finlay and Vredenburg 2007). For example, the gray-crowned rosy finch (*Leucosticte tephrocotis*), a high elevation Sierran bird that feeds extensively on adult mayflies emerging from lakes during the breeding season, is now less common at fish-containing lakes than fishless lakes (Epanchin et al. 2009). This difference is the result of nonnative fish feeding on mayfly larvae which severely reduces or eliminates mayfly emergence from lakes, resulting in a substantial loss of food for rosy finches.

Collectively, these processes result in a negative effect by nonnative fish on native species and high elevation aquatic and terrestrial ecosystems in the Sierra Nevada. However, these negative effects appear to largely disappear after nonnative fish either naturally die out or are actively eradicated from these systems (Knapp et al. 2001, Vredenburg 2004, Knapp et al. 2005, 2007). Although nonnative fish (trout) stocking was terminated in SEKI in 1988, recent research indicates that approximately 70% of previously-stocked lakes in SEKI have sufficient habitat to sustain trout populations in the absence of stocking (Zardus et al. 1977, Armstrong and Knapp 2004). Since trout typically live 6 to 7 years (Behnke 2002), and have been aged to 24 years in one high Sierra lake (Reimers 1979), all natural disappearances of nonnative trout in SEKI's high elevation waterbodies have likely already occurred. The remaining trout-containing waterbodies in SEKI's high elevations therefore contain self-sustaining fish populations that will continue to cause negative effects to these ecosystems unless they are eradicated by human intervention.

Other Impacts on High Elevation Ecosystems

The amphibian chytrid fungus (*Batrachochytrium dendrobatidis*) is a recently discovered fungal pathogen (Longcore et al. 1999) that 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. 2010A) 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 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. As a result, in 2007 the FWS reaffirmed the listing of the Sierra Nevada population of MYLFs as a federal candidate species under the Endangered Species Act (ESA; FWS 2007A).

Current studies indicate that both MYLF species are continuing to decline and are on trajectories toward extinction (Knapp et al. 2011). As a result, in 2012, *R. muscosa* was listed as endangered and *R. sierrae* was listed as threatened under the California Endangered Species Act (CFGC 2012), and in April 2014 both species were listed as endangered (FE) under the federal ESA (FWS 2014A). SEKI is the only park that contains both species of MYLFs, making it a core zone for their restoration, recovery, and conservation.

A few MYLF populations are showing evidence of persistence – surviving and reproducing while continuing to be infected (Vredenburg et al. 2010A; 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 instead of being extirpated.

Recent Aquatic Ecosystem Management Actions in SEKI

From 1997 to 1999, researchers used gill nets to experimentally eradicate nonnative fish from two park waterbodies, which showed that fish eradication was feasible. In 2001, SEKI began to implement preliminary (experimental) restoration of MYLFs. The *Environmental Assessment for the Preliminary Restoration of Mountain Yellow-legged Frogs* (NPS 2001, 2009) was established with a primary goal to assess the feasibility of SEKI staff using gill nets and electrofishers to eradicate nonnative fish from low- to moderate-use individual waterbodies 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 2013, SEKI removed 50,201 nonnative fish (Figure 2) from targeted waterbodies and streams (NPS 2015A, NPS unpublished data). By 2013, SEKI had fully eradicated fish from 10 waterbodies, nearly eradicated fish from 9 waterbodies, and began fish eradications in 4 waterbodies (initiated in 2012). MYLFs in nine of these waterbodies remained disease-free three years after fish removal. During this time average tadpole density in these 9 waterbodies increased by 13-fold (from 0.8 to 10.1 per 10 m of shoreline), while average frog density increased by 14-fold (from 0.8 to 11.1 per 10 m of shoreline) (NPS 2011A; Figure 3). One waterbody showed an overall 49-fold increase from 0.9 to 43.9 individuals per 32 ft (10 m) of shoreline. Several of these MYLF populations are now the largest in the Sierra Nevada. In addition, mountain garter snakes were more likely to be found in fish removal waterbodies versus fish-containing control waterbodies where no removal was conducted (NPS 2015A; see Figure 4 below). This difference is likely attributable to the presence of increased numbers of MYLFs (which are a primary prey of garter snakes) in fishless waterbodies versus fish-containing waterbodies (Knapp et al. 2007). These results show that using SEKI staff to eradicate nonnative fish using gill nets and electrofishers is feasible and beneficial to MYLFs and other native species at the local scale of individual or small groups of waterbodies.

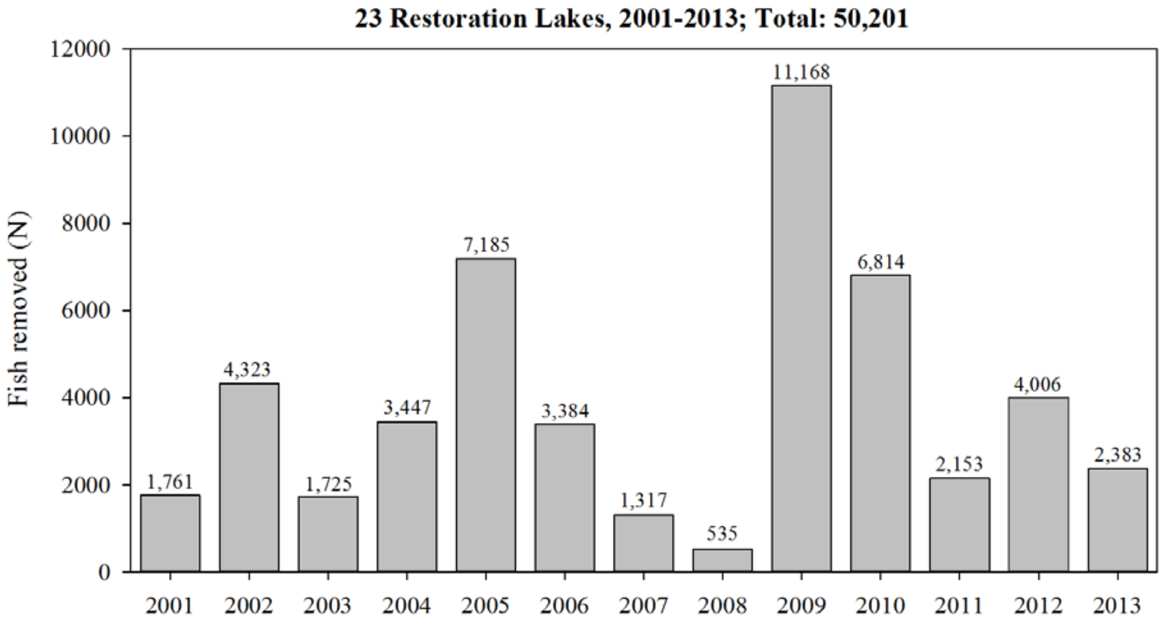

Figure 2. Nonnative fish removed per year from 2001 to 2013 in SEKI

Data are from 23 restoration lakes and adjacent streams in SEKI, including six lakes begun in 2001, five lakes begun in 2004 and 2005, seven lakes begun in 2009, one lake begun in 2010, and four lakes begun in 2012. Through 2013, nonnative fish eradications have been completed in 10 lakes, nearly completed in 9 lakes, and in-progress (recently initiated) in 4 lakes. From 1997 to 1999, researchers eradicated nonnative fish from two additional lakes in SEKI; those fish removal numbers are not included in this figure.

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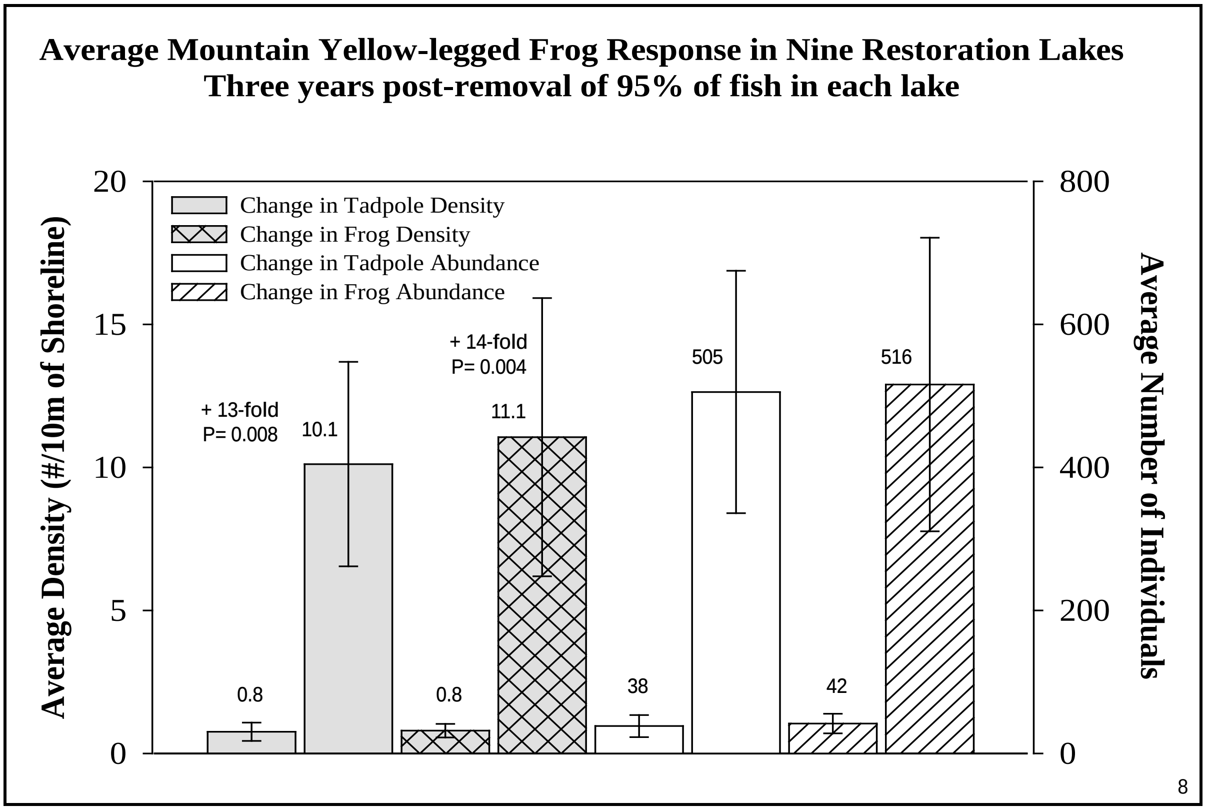

Figure 3. Average MYLF response to fish removal in SEKI

Average density (number per 32 ft (10 m) of shoreline per survey) and average abundance (number per survey) of mountain yellow-legged tadpoles and frogs in nine restoration lakes in SEKI after removal of 95% of fish in each lake. Amphibian chytrid fungus was not present in any of the restoration nine lakes during this 3-year period. Baseline averages (left bar of each pair) derived from surveys from the initial year of restoration in each lake, and response averages (right bar of each pair) derived from surveys conducted three years after the year in which 95% of fish were removed from each lake. One to three surveys were conducted per lake before and after fish removal.

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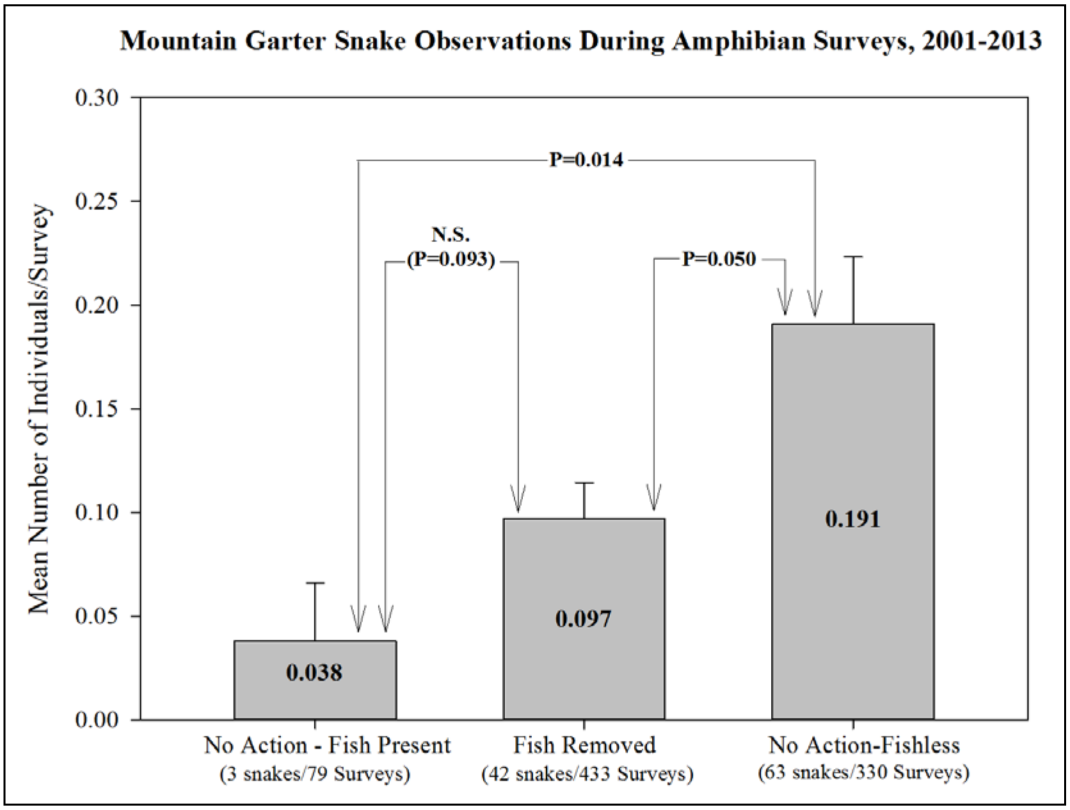

Figure 4. Number of mountain garter snakes observed from 2001 to 2013 in SEKI

Mountain garter snakes detected per survey (+1standard error) in three treatment categories. Three snakes were detected in 79 surveys in lakes where fish were present, 42 snakes were detected in 433 surveys in lakes where fish were being removed, and 63 snakes were detected in 330 surveys in long-term fishless lakes. A "Mann-Whitney U" test measured a significant difference (p=0.014) in the number of garter snakes detected per survey in fish-containing lakes ($\bar{x}$=0.038) versus fishless lakes ($\bar{x}$=0.191). A significant difference (p=0.050) was also measured in fish removal lakes ($\bar{x}$=0.097) versus fishless lakes ($\bar{x}$=0.191). In comparison, the number of garter snakes observed per survey in fish removal lakes ($\bar{x}$=0.097) was not significantly different (p=0.093) than in fish-containing lakes ($\bar{x}$=0.038). Although snakes were detected more often in fish removal lakes versus fish-containing lakes, it is hypothesized that not enough time has passed in fish removal lakes to allow for full recovery of native biota. In addition, continued impacts from amphibian chytrid fungus have reduced or eliminated the ability of MYLFs to recolonize restoration habitat, or caused restored MYLF populations to later decline when they became infected.

Other Legislation, Guidance, and Previous Planning

The NPS uses planning to bring logic, analysis, public involvement and accountability into the decision-making process while ensuring that the decisions it makes will carry out, as effectively and efficiently as possible, its mission:

> "The National Park Service preserves unimpaired the natural and cultural resources and values of the national park system for the enjoyment, education, and inspiration of this and future generations. The Park Service cooperates with partners to extend the benefits of natural and cultural resource conservation and outdoor recreation throughout this country and the world."

The NPS mission, along with applicable laws, policies and plans, directs resources management and science within SEKI. The following laws, policies and plans, in addition to those identified in the "Objectives of the Restoration Program" section, provide direction for management of aquatic resources within SEKI and are relevant to the planning effort for this Restoration Plan/FEIS.

In addition to determining the environmental consequences of implementing the preferred and other alternatives, NPS *Management Policies 2006* (section 1.4) requires analysis of potential effects to determine whether or not proposed actions would impair a park's resources and values. As required, an impairment determination will be included in the record of decision for the plan.

The *National Wild and Scenic Rivers Act of 1968* (WSRA; 16 USC § 1271 et seq.) establishes the national wild and scenic rivers systems to preserve and protect selected rivers, or segments of rivers, in their free-flowing condition. Section 1(b) of the WSRA states that "certain selected rivers of the Nation which, with their immediate environments, possess outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values, shall be preserved in free-flowing condition, and that they and their immediate environments shall be protected for the benefit and enjoyment of present and future generations."

Of the major watersheds within SEKI – the North Fork of the Kern River (28.9 mi) and the Middle and South Forks of the Kings River (53.6 mi) are designated as "wild," which means rivers or sections of rivers that are free of impoundments and generally inaccessible except by trail, with watersheds or shorelines essentially primitive and waters unpolluted. A short segment of the South Fork of the Kings River (7.6 mi) is designated as "recreational," which means rivers or sections of rivers that are readily accessible by road or railroad, that may have some development along their shorelines, and that may have undergone some impoundment or diversion in the past. However, these designated wild and scenic river segments are not within the treatment areas included in the proposed alternatives; they are of varying distances downstream from the nearest treatment area.

The *Clean Water Act*, as amended (33 USC § 1251 et seq.), passed in 1972 as an amendment to the *Federal Water Pollution Control Act*, was designed to restore and maintain the integrity of the nation's water. It establishes effluent limitation for new and existing industrial discharge into U.S. waters; authorizes states to substitute their own water quality management plans developed under section 208 of the act for federal controls; provides an enforcement procedure for water pollution abatement; requires permits for point source discharges to waters of the United States; and requires permits for actions that may result in discharge of dredged or fill material into a tributary to, wetland, or associated water source for a navigable river.

The *Federal Insecticide, Fungicide, and Rodenticide Act of 1972* (7 USC § 136 et seq.) regulates the distribution, sale and use of pesticides by providing a system of registration, labeling and use of pesticides to protect applicators, the public and the environment. Use of each registered pesticide must be consistent with use directions contained on the label or labeling. The Act establishes a system of examination and certification for applicators.

The *Migratory Bird Treaty Act***,** *as amended* (16 USC § 703 et seq.) includes prohibitions against the taking, capturing, or killing of migratory birds, except under the terms of a valid permit issued pursuant to Federal regulations. *Executive Order 13186 – Responsibilities of Federal Agencies to Protect Migratory Birds* clarifies the responsibilities of Federal agencies to protect migratory birds including reducing the unintentional take of migratory birds. The NPS and the FWS entered into a *Memorandum of Understanding between the U.S. Department of Interior National Park Service and the U.S. Fish and Wildlife Service to Promote the Conservation of Migratory Birds* in April 2010. This MOU established how the two agencies would work together to promote conservation of migratory birds that include the incorporation of mitigation measures to reduce unintended take as defined by Executive Order 13186.

Relevant State Legislation

The *California Environmental Quality Act* (CEQA; California Public Resources Code, Section 21000 et seq.) was passed in 1970 in response to the passage of NEPA in 1969. This Act is California's broadest environmental law and requires state and local agencies to identify the significant impacts of their actions and to avoid or mitigate those impacts, if feasible. Federally sponsored and financed projects involving a state or local agency and a federal agency are subject to both NEPA and CEQA review. This project involves collaboration with the California Regional Water Quality Control Board, Sierra Nevada Conservancy, and CDFW, thus this NEPA document also complies with CEQA.

The *California Food and Agricultural Code* (Sections 11704, 14151-14155) mandates the California Department of Pesticide Regulation to regulate the use pesticides in California. The application of federally restricted use pesticides or state restricted materials is addressed through a Qualified Applicator Certificate program (Title 3, California Code of Regulations, Section 6000 et seq.). While federal employees are not subject to the state's licensing requirement, SEKI would ensure that its staff receive equivalent training prior to applying any regulated pesticides.

Relationship to Other Planning

SEKI-Specific Planning Documents and Other Guidance

The key park planning documents that affect this project are the parks' *Final General Management Plan/Final Environmental Impact Statement* (NPS 2007), *Natural and Cultural Resources Plan* (RMP; NPS 1999), and the *Wilderness Stewardship Plan* (WSP; NPS 2015B), Collectively, these documents guide SEKI's philosophy and practices in managing natural and cultural resources and wilderness quality within the parks while providing for appropriate types and levels of visitor use.

The 2007 SEKI GMP establishes a vision for what the parks should be, including broadly defined desired future conditions for natural and cultural resources and visitor experiences. The GMP also includes a comprehensive river management plan for rivers within SEKI that have been designated by Congress as components of the national wild and scenic rivers system. The GMP reiterated the goals and objectives of the 1999 RMP.

The GMP broadly established desired conditions for various natural resources. Many desired conditions are relevant to this Restoration Plan/FEIS, including:

> 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 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.
>
> 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 maintain all the components and processes of naturally evolving park ecosystems.
>
> 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.

> 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 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.
>
> The natural and beneficial values of wetlands are preserved and enhanced.
>
> The NPS will avoid, whenever possible, the pollution of park waters by human activities occurring within and outside parks.
>
> NPS and NPS-permitted programs and facilities are maintained and operated to avoid pollution of surface and ground waters.
>
> Protection of stream features will primarily be accomplished by avoiding impacts to watershed and riparian vegetation, and by allowing natural fluvial processes to proceed unimpeded.

The 1999 SEKI RMP provides the foundation for the parks' resource stewardship programs. It identifies goals, describes existing resource conditions and how they differ from the desired future conditions envisioned in the goals, identifies major issues and stressors that are causing divergence from the desired future conditions, and outlines a strategy for addressing each major issue.

The RMP recognizes that aquatic communities have been altered and impacts have included a decline in both native invertebrate and vertebrates, with the "*precipitous decline of the MYLF being one of the most notable*." Resource management goals identified in the RMP relevant to this planning effort includes the following objectives:

> Aquatic and water ecosystems are restored/and or maintained so that physical, chemical, and biotic processes function uninfluenced by human activities.
>
> Lakes with exotic trout are restored to natural conditions.
>
> Extant native species or genetically unique groups are restored to their former range.
>
> Native animal species and threatened/endangered and sensitive animal species are inventoried, monitored, protected, and restored/maintained over time.
>
> Exotic animal species are controlled/contained where feasible.

SEKI is updating the RMP with a Resources Stewardship Strategy (expected completion in late 2016). The RSS will recommend science-based approaches to achieve and maintain the desired conditions of the parks' natural and cultural resources. It will focus on ways to conserve natural and cultural resources in an era of rapid change and uncertain conditions. The RSS will apply to all areas of the parks. The conservation goals outlined in the RSS will adhere to the law and the mission of the NPS and use the best available science to adaptively manage for the long-term. Strategies to conserve native regional biodiversity and ecological integrity, and to preserve cultural values, will be identified in the RSS. The goals and objectives in this plan would be incorporated into the RSS.

The SEKI WSP was finalized in 2015 (NPS 2015B). It establishes a framework for the management of wilderness within the parks in order to preserve wilderness character and provide opportunities for access and use in accordance with the Wilderness Act and other laws and policies. The WSP focuses on providing visitors with opportunities for solitude and/or a primitive and unconfined recreation, managing impacts related to visitor use to preserve wilderness character, and determining the administrative actions necessary to protect the parks' wilderness character. One of the primary goals and objectives of the WSP is to: Preserve ecological, geological, scientific, educational, scenic, and historical values of wilderness, consistent with the Wilderness Act, California Wilderness Act, and applicable planning guidance from the GMP.

The WSP also establishes desired conditions for natural and cultural resource that the NPS aspires to achieve and maintain over time. Some desired conditions may not be fully attainable due to factors unrelated to visitor use or the parks' management activities (e.g., due to external factors such as climate change and air pollution).

The desired conditions from the WSP that are relevant to this Restoration Plan/FEIS include:

- The untrammeled quality of wilderness character will be preserved by limiting deliberate manipulation of ecological systems except as necessary to promote another quality of wilderness character.
- The natural quality of wilderness will be preserved by mitigating the impacts of modern civilization on ecosystem structure, function, and processes. The NPS aspires to minimize or localize adverse impacts caused by visitor use and administrative activities. In the wilderness, natural processes will dominate:
    - ecosystem structure and function
    - native biodiversity
    - water quality and quantity
    - decomposition, nutrient cycling, and soil forming processes
    - meadow and wetland productivity
    - fire regimes
    - soundscapes, dark skies, and viewsheds.

The WSP supports the continuation of relevant scientific research in wilderness, using methods that preserve wilderness character. Scientific investigations will continue to be conducted in wilderness to enable the NPS to meet its mission requirements and the ecological, geological, scientific, conservation, and historic purposes of the Wilderness Act. Minimum requirements analyses (MRAs) will be conducted to determine whether each proposed project is administratively necessary and, if it is, to select the minimum tool. In addition, if a 4(c) prohibited use is proposed, or if a project has the potential to adversely affect wilderness resources, the actions would be evaluated through a MRA process. The MRA for this plan is contained in appendix A.

Other Relevant Plans and Actions Reviewed and Considered

The following plans and actions are relevant to this Restoration Plan/FEIS due to their focus on fish eradication, native species restoration or conservation, and/or research of high elevation aquatic ecosystems. In summary, they describe that fish eradication is feasible, and that other parks and agencies have used piscicides successfully and without unacceptable environmental effects. SEKI has reviewed these other projects to integrate results and findings, as applicable, to this Restoration Plan/FEIS.

This Restoration Plan/FEIS is aligned with the NPS Natural Resources Adaptation Strategy, a national NPS initiative, enhancing all of the elements identified to make natural systems more resilient to climate change. Nonnative trout eradication and MYLF disease treatments in large lake complexes would create (1) climate refugia that will persist as reliable high-quality habitat for endangered MYLFs and other native species as climate changes; (2) fish-free, within-basin migration corridors for MYLF populations to effectively function as metapopulations; (3) populations of MYLFs that maintain existing genetic diversity and promote conditions for increased diversity over time; and (4) large blocks of landscape lacking nonnative trout and mitigated for disease to enhance resilience to disturbance and change over time. In addition, this Restoration Plan/FEIS would create multiple climate refugia (large fish-free lake complexes) and restored MYLF populations in each of three MYLF genetic clades known to occur in SEKI, which simultaneously restores habitat, native species and natural processes across the geographic and elevational extent of SEKI's high elevation aquatic ecosystems.

YOSE has completed the *Wilderness Sierra Nevada Yellow-legged Frog Translocation and Trout Eradication Project/Categorical Exclusion* (SNYLF Plan/CE; NPS 2012B) to address the dramatic decline of the Sierra Nevada yellow-legged frog, an endemic species that has declined by at least 93%. The SNYLF Plan/CE is a 5-year plan that provides for: (1) fish eradication to restore high-quality SNYLF habitat at up to 18 lakes, ponds, marshes, meadows, and associated streams using gill nets, electrofishers, and fish traps; (2) experimental translocations at three sites including the use of Itraconazole to clear frogs of amphibian chytrid fungus and *Janthinobacterium lividum* a naturally occurring bacteria that is thought to reduce the impacts from amphibian chytrid fungus; and (3) long-term monitoring including the collection of swabs to monitor amphibian chytrid fungus infection rates and the implantation of Passive Integrated Transponder (PIT) tags to monitor the survivorship of individual frogs. While there has been much coordination among staff from both parks on nonnative fish eradication protocols, the scope of YOSE's plan is different from SEKI's current proposal.

Because this is YOSE's initial attempt at implementing aquatic restoration on a program level, the park is proposing to recover relatively simple habitat (focusing on isolated individual lakes, ponds, marshes, and meadows with short stream segments leading up to distinct fish barriers) using methods recently proven successful by SEKI and CDFW in other Sierra Nevada locations. These methods include restoring individual lakes that have short associated streams from which nonnative fish can be eradicated using gill nets, electrofishers, and trapping, which are similar to those that SEKI treated under its current plan.

This SEKI Restoration Plan/FEIS is proposing to recover smaller relatively simple habitats using physical tools, and larger more complex habitats (including whole basins) using alternative tools. These habitats are collectively important for conservation of native species, ecosystems and processes, and for mitigating potential effects from climate change. Because eradication of nonnative fish from larger, more complex habitats has been determined infeasible using gill nets and electrofishers, SEKI is considering other alternatives, including the use of piscicides, in order to restore these ecologically significant habitats.

Similar projects have been approved and implemented in other national park units (Table 4), including projects in North Cascades National Park Complex (NOCA). In 2008, NOCA completed a *Final Mountain Lakes Fishery Management Plan/ Environmental Impact Statement* (NPS 2008A) to guide its future fisheries management. The action selected allows for the elimination of high densities of reproducing fish populations from up to 27 lakes using several methods of fish removal including: (1) spawning habitat exclusion (to break the cycle of reproduction in lakes with limited spawning habitat); (2) gill netting combined with electrofishing and trapping; and (3) application of the piscicide antimycin A. In 2009, NOCA treated a cluster of two lakes and connecting streams with antimycin A. Assessment surveys in 2010 using gill nets and electrofishers did not detect any fish, indicating eradication ws achieved in one treatment (Rawhouser A., pers. comm. 2011). Products containing antimycin A have also been used in other national parks to successfully eradicate nonnative fish from lakes and streams in conjunction with native habitat restoration efforts, including SEKI (1979), Yellowstone (YELL; 1975, 1977, 1985), Mount Rainier (1986), Rocky Mountain (1987, 1988, 1990, 1996), Crater Lake (2000 to 2005, 2012 to 2013), Great Smoky Mountains (GRSM; 2000, 2003, 2005, 2008), and Great Basin (GRBA; 2002, 2004). In 2000, GRBA also used the piscicide rotenone in one treatment area to evaluate the results of using antimycin A or rotenone for fish eradication.

Products containing rotenone have also been used in other national parks to successfully eradicate nonnative fish from lakes and streams in conjunction with native habitat restoration efforts, including YELL (1938, 2006, 2008, 2011 to 2014), GRSM (1957), Mount Rainier (1965), YOSE (1965, 1966), and Golden Gate National Recreation Area (2014). In the 2006 and 2008 applications in YELL, the NPS used rotenone to eradicate nonnative fish from one lake and its outlet stream (approximately 10 mi long), in order to create a refuge for threatened westslope cutthroat trout (NPS 2006B). This project achieved eradication in one treatment from the targeted lake and several miles of downstream habitat. In the three rotenone treatments in YELL from 2011 to 2014, fish were eradicated in one treatment from a lake complex, and in 2 to 3 treatments from two large stream areas.

YELL selected rotenone instead of antimycin A due to a quality control issue in the manufacturing of antimycin A that caused at least one piscicidal application to fail in eradicating nonnative fish (Ruhl M., pers. comm., 2007). This issue was apparently rectified as the antimycin A treatment by NOCA in 2009 was successful (Rawhouser A., pers. comm., 2011). YELL recently completed their Native Fish Conservation Plan/Environmental Assessment (NPS 2012C). This plan includes the use of approved piscicides (rotenone and antimycin A) to remove nonnative or hybridized fish from selected streams, lakes, and rivers to restore native Yellowstone cutthroat trout, westslope cutthroat trout, and arctic grayling. This project also included the construction of artificial barriers or modification of existing natural features (cascades or small waterfalls) to create a complete barrier to upstream fish movement.

In 2013, when antimycin A was no longer available, NOCA conducted a risk characterization to switch to the CFT Legumine™ rotenone formulation for ongoing piscicide treatments (NPS 2013B). In 2013 and 2014, NOCA conducted single-lake piscicide treatments using CFT Legumine™ and successfully eradicated fish each time using one treatment (Table 4). In 2015, they conducted an additional piscicide treatment using CFT Legumine™ that appears to have been successful eradicating fish using one treatment; this will be re-evaluated in 2016 (NPS 2015C, Rawhouser, A., pers. comm., 2016).

Table 4 shows piscicide treatments using either rotenone or antimycin A that have been implemented in NPS units since 1987, with several occurring in the past decade. Piscicide treatments were successful in eradicating fish from 23 of 25 sites. Some of these NPS units also removed fish using physical methods. See chapter 4 for detailed discussion of the effects of the above projects and similar projects on non-target species and water quality.

The USFS has a research program entitled *Development and Evaluation of National Protocol for Monitoring Vertebrate Populations and their Habitats at the Ecoregional Scale*. The program's objectives are to develop and evaluate sampling designs, detection protocols and analysis procedures for multiple species of vertebrates and their habitats at ecoregional scales; and to develop national guidance in the form of a National Forest System technical guide that outlines how to monitor populations and habitats of multiple species in one integrated design. The USFS has developed and is testing the "Multiple Species Inventory and Monitoring Protocol," which is intended to meet basic population and habitat monitoring information needs for the National Forest System.

Another USFS research project is *Linking Frog Population Monitoring with the Forest Inventory and Analysis Grid: Data Efficiencies and Sample Design Challenges*. This research focuses on monitoring frog populations with particular emphasis on MYLFs and the Yosemite toad, spatially collocating data collection on amphibian populations with data collection on other species and habitats.

The USFS *Atmospheric Sciences Research* program focuses on forested ecosystems. However, it is relevant to this Restoration Plan/FEIS in that it has increased understanding of impacts of air pollution and acidic deposition on forested watersheds and aquatic ecosystems.

Table 4. History of fish removal projects using piscicide treatments in NPS units since 1987*

National Park	Years	Site	Lake and Stream Amounts	Number of Treatments	Additional Methods	Treatment Notes
Crater Lake	2000-2005	Sun Creek	11.2 miles	3	Electrofishing: 1992	Successful after two treatments (third was precautionary).
	2012-2013	Sun Creek	8 miles	2		
Golden Gate NRA (Presidio)	2014	Mountain Lake	1 lake	1	Physical: 2012	
Great Basin	2000	Strawberry Creek	7.4 miles	1		
	2002	Snake Creek	4.7 miles	2		Large area.
	2004	Johnson Lake	1 lake	2		1st treatment failed due to pH and other issues.
Great Smoky	2000	Sams Creek	3 miles	2	Electrofishing: 1996	First treatment failed due to autumn leaves.
	2003	Bear Creek	3.5 miles	1		
	2005	Indian Flats Prong	1.5 miles	1		
	2008	Lyn Camp Prong	8.5 miles	1		
North Cascades	2009	Blum	2 lakes, some stream	1	Physical: 2009	
	2013	Sourdough Lake	1 lake	1		
	2014	Kettling Lake	1 lake	1		
Pictured Rocks	1987	Spray Creek	unknown	1		Eradication not achieved, but goals unclear based on available record (eradication may not have been desired outcome).
	1987	Section 34 Creek	unknown	1		
Rocky Mountain	1987	Lower Hutcheson Lake and Cony Creek	1 lake, unknown miles	1		
	1988	Pear Lake and Cony Creek	1 lake, unknown miles	1		
	1988	Sandbeach Lake	1 lake	1		
	1990	Spruce and Loomis Lake	2 lakes	1		
	1996	Dream Lake	1 lake	1		
Yellowstone	2006	High Lake	1 lake	1	Physical: 1995-Present	
	2008	Specimen Creek	10 miles	2		
	2011	Goose Creek	2.5 mile, 3 lakes	1		
	2012-2014	Elk Creek	many miles	3		Dense woody debris.
	2013-2014	Grayling Creek	59 miles	2		

**Three additional piscicide treatments in NPS units occurred in 2015, including Skymo Lakes in North Cascades, Soda Butte Creek in Yellowstone, and a backwater slough off of the Colorado River in Glen Canyon National Recreation Area. Results from these treatments are forthcoming.*

Other similar ecosystem recovery efforts are ongoing in California. The CDFW prepared a programmatic Environmental Impact Report (EIR) entitled *Rotenone Use for Fisheries Management* (CDFW 1994) to assess potential impacts of CDFW fisheries management programs and to outline best management practices to minimize environmental effects. In 1997, CDFW treated Lake Davis, a reservoir, with rotenone to eradicate nonnative northern pike (*Esox lucius*). Although initial results appeared to confirm eradication, northern pike were detected in Lake Davis in 1999. It was never known whether the eradication was unsuccessful or northern pike were illegally reintroduced (Lee 2001). Nevertheless, due to increasing effects of northern pike on the valued rainbow trout fishery in Lake Davis, the local community and the government supported a second rotenone treatment in 2007 (CDFW 2007), which was successful in eradicating the northern pike population (Lentz and Clifford 2014).

The FWS published the Revised Recovery Plan for the Paiute Cutthroat Trout (FWS 2004). The goal of the Recovery Plan is to develop self-sustaining populations of the threatened Paiute cutthroat trout to enable delisting from the federal list of threatened and endangered species. The criteria of the Recovery Plan include: removal of all nonnative trout in Silver King Creek and its tributaries from downstream of Llewellyn Falls to the fish barriers in Silver King Canyon; restoration of a viable population to all historic habitat in Silver King Creek and its tributaries from Llewellyn Falls to the impassable barriers in the Silver King Canyon; maintenance of Paiute cutthroat trout in all occupied streams; maintenance of out-of-basin populations as refugia; and development of a long-term conservation plan and agreement.

The FWS and CDFW, in cooperation with the USFS, prepared a joint EIS/EIR for the *Paiute Cutthroat Trout Restoration Project, Silver King Creek, Humboldt-Toiyabe National Forest, Alpine County, California* (FWS 2010) to analyze implementation alternatives supporting the Recovery Plan. The project was approved to eradicate nonnative trout species from 11 mi (18 km) of Silver King Creek and its tributaries. The method involved the use of liquid rotenone formulation CFT Legumine™ at a concentration ranging from 0.5 to 1.0 parts per million (ppm) and the use of potassium permanganate to neutralize the rotenone. Implementation occurred from 2013 to 2015 and eradication success will be evaluated in 2016 (Mussulman, S., pers. comm., 2016).

Since 1999, CDFW has been eradicating nonnative fish from individual lakes, ponds, and their associated short stream segments in Sierra Nevada national forests using gill nets and electrofishers in order to restore native fauna. As of 2010, CDFW has restored or is in the process of restoring 48 lakes by removing nonnative trout (CDFW 2011). Twenty-five of these sites are adjacent to MYLF populations. Monitoring surveys are being conducted at fish removal sites to describe MYLF abundance before, during, and after fish removal. Survey results demonstrate that the average number of frogs counted at each site increased 12-fold following fish removal (from 4 to 47 per survey), and the average number of tadpoles counted increased 20-fold (from 10 to 198 per survey; CDFW 2011).

The USFS initiated physical removal of trout at seven lakes in the Desolation Wilderness in 2008. As of 2011, all seven of the lakes were restored to their naturally fishless condition. Monitoring occurred at all lakes in 2012 to ensure success. Research efforts were initiated in 2013. Wild and captive frogs were translocated in two of the seven restored lakes in 2014 and a third lake in 2015. Translocations will continue in 2016.

The USFS initiated physical removal of trout at seven lakes in the Desolation Wilderness in 2008. As of 2011, all seven lakes were restored to their naturally fishless condition. Monitoring occurred at all lakes in 2012 to measure success, and research was initiated in 2013. Wild and captive frogs were translocated to two of the seven restored lakes in 2014 and a third lake in 2015. Many MYLFs have survived thus far, and additional translocations will occur in 2016.

PURPOSE AND SIGNIFICANCE OF SEQUOIA AND KINGS CANYON NATIONAL PARKS

An essential part of the planning process is understanding the purpose, significance, and mission of the parks for which this FEIS is being prepared. The enabling legislation for SEKI, together with the NPS Organic Act and its amendments discussed previously, provides the overall purpose of the parks. The SEKI GMP reinforced the purpose and significance of the parks, establishing the overall management direction and mission for the parks. The following is a summary of legislation related to the establishment of SEKI.

Enabling Legislation
Sequoia National Park was established as the nation's second national park on September 25, 1890. Congress directed that Sequoia National Park be a place "dedicated and set apart as a public park, or pleasure ground, for the benefit and enjoyment of the people," and that it be managed "for the preservation from injury of all timber, mineral deposits, natural curiosities or wonders. . .[and for] their retention in their natural condition" (16 USC 41, 26 Stat. 478).

On October 1, 1890, legislation was enacted that tripled the size of the park and established General Grant National Park, extending the same protection to the new areas (26 Stat. 650). The Act of July 3, 1926 again enlarged Sequoia National Park (16 USC 688, 44 Stat. 818) and instructed the Secretary of the Interior to establish regulations aimed at "the freest use of said park for recreational purposes by the public and for the preservation from injury or spoliation of all timber, natural curiosities, or wonders within said park and their retention in their natural condition. . . and for the preservation of said park in a state of nature so far as is consistent with the purposes of this Act."

Kings Canyon National Park was established on March 4, 1940, absorbing General Grant National Park lands (16 USC 80, 54 Stat. 41). The park was "dedicated and set apart as a public park … for the benefit and enjoyment of the people." On August 6, 1965, Cedar Grove and Tehipite Valley were added to Kings Canyon National Park (79 Stat 446, Pub. L. 89–111).

The National Parks and Recreation Act of November 10, 1978 (PL 95-625), added USFS lands in the Sequoia National Game Refuge to Sequoia National park to "assure the preservation. . .of the outstanding natural and scenic features of the area commonly known as the Mineral King Valley. . .and enhance the ecological values and public enjoyment of the area."

On June 2, 1920, the United States accepted sole and exclusive jurisdiction over Sequoia National Park after it was ceded by California on April 15, 1919. This left Sequoia National Park solely responsible for the management of its resources except for California retaining the right to fix and collect license fees for fishing (16 USC 57). On April 7, 1943, California ceded jurisdiction of Kings Canyon National Park, but retained the right to fix and collect license fees for fishing.

Park Purposes
Sequoia and Kings Canyon National Parks are two separate national parks which share miles of boundary and are managed together as one park unit. The purpose of Sequoia and Kings Canyon National Parks as defined in the parks' GMP is as follows:

> Protect the greater Sierran ecosystem—including the sequoia groves and high Sierra regions of the park—and its natural evolution forever.
>
> Provide appropriate opportunities to present and future generations to experience and understand park resources and values.
>
> Protect and preserve significant cultural resources.
>
> Champion the values of national parks and wilderness.

Park Significance
Park significance statements capture the essence of a national park's importance to the natural and cultural heritage of the United States. Significance statements do not inventory park resources; rather, they describe the park's distinctiveness and help place the park within the regional, national, and

international context. Defining park significance helps managers make decisions that preserve the resources and values necessary to accomplish the purpose of the national park. Sequoia and Kings Canyon National Parks are significant because they contain the following resources (NPS 2007):

> The largest giant sequoia trees and groves in the world, including the world's largest tree, the General Sherman tree
>
> An extraordinary continuum of ecosystems arrayed along the greatest vertical relief (1,370 to 14,494 ft/418 to 4,418 m in elevation) of any protected area in the lower 48 states
>
> The highest, most rugged portion of the high Sierra, which is part of the largest contiguous alpine environment in the lower 48 states
>
> Magnificent, deep, glacially carved canyons including Kings Canyon, Tehipite Valley, and Kern Canyon
>
> The core of the largest area of contiguous designated wilderness in California—the second largest in the lower 48 states
>
> The largest preserved southern Sierra foothills ecosystem
>
> More than 260 known marble caverns, many inhabited by cave wildlife that is found nowhere else
>
> A wide spectrum of prehistoric and historic sites documenting human adaptations in their historical settings throughout the Sierran environments

Sequoia and Kings Canyon National Parks have been designated as an international biosphere reserve, a program under the United Nations Educational, Scientific, and Cultural Organization that recognizes resources with worldwide importance. While this designation does not grant any form of control or ownership to the international body, it underscores the exceptional and singular qualities of the parks.

Park Mission

Park purpose describes the specific reason the park was established. Park significance is embodied in the distinctive features that make the park different from any other. Together, purpose and significance lead to a concise statement: the mission of these parks. The mission of Sequoia and Kings Canyon National Parks is to preserve and provide for the enjoyment of present and future generations the wonders, curiosities, and evolving ecological processes of the southern Sierra Nevada—including the largest giant sequoia trees in the world, freeflowing wild and scenic rivers, and the heart of the vast High Sierra wilderness (NPS 2016).

ISSUES AND IMPACT TOPICS

Scoping

Internal scoping for this project began in January 2007 when the proposal was initially presented to the parks' interdisciplinary planning team. In developing a strategy to restore frogs and their aquatic habitats, the parks solicited advice from experienced wilderness rangers who are familiar with where people fish and considered comments from the public regarding recommendations on places where they wished to preserve angling opportunities. This information was considered together with frog restoration objectives, historic populations, and habitat quality to optimally achieve the needs of both restoration and angling.

On January 17, 2007, SEKI initated public scoping and released a public scoping brochure for the restoration of mountain yellow-legged frogs and high elevation lakes and streams environmental analysis. The brochure included background information on the proposed project, several preliminary alternatives, and a scoping comment form to assist the public with providing scoping comments. The scoping brochure was mailed to approximately 100 individuals, tribes, organizations, and agencies on the parks' mailing list. A news release announcing public scoping was also distributed to approximately 135 media outlets (see appendix D).

Public scoping was conducted from January 17 to February 6, 2007, but comments were accepted as late as April. During that time, the parks' received comments from 35 different sources (several people submitted more than one comment letter). Six of the comment letters received were from organizations: High Sierra Hikers Association, Wilderness Watch, California Trout, Californians for Western Wilderness, National Parks and Conservation Association, and Californians for Alternatives to Toxics. Five commenters were affiliated with universities, three with businesses, one was affiliated with the U.S. Forest Service, and 22 comments were from unaffiliated individuals.

In late 2007, a newsletter providing an update on the environmental analysis status was sent to approximately 100 individuals, agencies, interest groups, and tribes on the parks' mailing list including all those who provided comments during the scoping period. As a result of the newsletter, four additional comment letters were received between May 2007 and November 2008 and are included in the administrative record. Two of those letters were from unaffiliated individuals (one had previously submitted comments), and two were from organizations, Western Environmental Law Center and High Sierra Hikers Association (previously submitted comments). In total, 37 different individuals, groups, businesses, or agencies submitted comments on the proposed project.

In late 2007, parks staff began writing an environmental assessment for the proposed project. As staff prepared the EA, including preparing the environmental analysis for the proposed project, and re-reviewed the public input on the proposal, it became clear that the project had the potential for significant impacts on the human environment associated with the potential for controversy, uncertain and potentially significant environmental effects (beneficial and adverse), and unique and unknown environmental effects. For these reasons, and in accordance with the NEPA section 102 (2) (C), in early 2009, the superintendent determined that an EIS would be more appropriate for this project.

A notice of intent to prepare an EIS was published in the *Federal Register* for this project on October 7, 2009 (Vol. 74, No. 193). Simultaneously, the NPS provided information on the proposed project with a press release and/or letter by email or mail to more than 380 individuals, interest groups, agencies, and businesses on the parks' mailing list, and to 32 area tribes or tribal representatives. Two public meetings were held to provide information on the proposed project during the scoping period: Fresno (November 13, 2009) and Three Rivers (November 5, 2009). The SEKI Aquatic Ecologist presented background information on the proposal. The public was invited to ask questions and discuss issues during the presentations. There were 17 participants at the Three Rivers meeting and 8 participants at the Fresno meeting. All information and questions provided by participants was documented and is included in the scoping report (available at http://parkplanning.nps.gov/seki).

Information about the project scoping was picked up by the Associated Press and was published in area newspapers and on the internet on various public and government websites. Local area newspapers that published stories related to the rpoposed project scoping in 2009 included: The Kaweah Commonwealth (October 30), The Visalia Times Delta (October 27), and The Fresno Bee (October 26). Websites included: abclocal.go.com (October 26); cbs13.com (October 26); mercedsunstar.com (October 26); kcbs.com (October 26); fresnobee.com (October 26); ksrw.sierrawave.net (October 7); Save the Frogs (November 18); treehugger.com (November 22); National Parks Traveler (November 20); Sierra Forest Legacy (November 12); and, redding.com (October 30). The story was broadcast on "The California Report" (November 16), which airs on various local radio stations in California. In addition, further information was provided on the proposed project after scoping ended at Golden Gate Press (December 3) and at alternatives2toxics.org (December 16).

There were 709 comment letters received during the October 7 to November 21, 2009 scoping period. Commenters provided input by a variety of methods, including letters, email, hand delivery, and through the NPS Planning, Environment, and Public Comment (PEPC) system. Of the 709 comment letters, 652 were form letters, 54 letters were from individuals, 2 were from businesses, and 2 were from interest groups or their representative.

In addition to the scoping meetings, alternatives presentations and workshops were held in the area to engage the public during the development of alternatives. All scoping commenters plus those on the project mailing list were notified of the meetings (approximately 1,000 people) by either email or regular mail. The meetings were held on March 23, 2010, in Visalia, California (no attendees), on March 30, 2010 in Bishop, California (eight attendees), and on April 5, 2010, in Three Rivers, California at the monthly Town Hall meeting (approximately 40 attendees). Between March 11 and April 12, 2010, draft conceptual alternatives were made available from the parks' internet page and through PEPC, and comments were accepted and considered on those alternatives. Eight comment letters were received during the alternatives review period; none provided new alternatives or additional new substantive comments.

Public Review of the Restoration Plan/DEIS

The Restoration Plan/DEIS (NPS 2013A) was available to the public, federal, state, and local agencies, tribes, and organizations for a 60-day public review period starting September 26, 2013. A Notice of Availability (NOA) was published in the Federal Register on October 1, 2013. The NPS posted electronic copies of the Restoration Plan/DEIS to the NPS Planning, Environment, and Public Comment (PEPC) website at http://parkplanning.nps.gov/aquatics and provided printed or CD copies of the Restoration Plan/DEIS to 138 interested parties on the parks' mailing list and to those who requested them. A printed copy was provided to 23 area public libraries in Tulare, Inyo, Fresno, and Kern counties. In addition, notification of the Restoration Plan/DEIS was sent by email or regular U.S. mail to 1,309 people on the parks' mailing list. A news release was distributed to media outlets, and was placed on the parks' website. In October 2013, due to the shutdown of the federal government, and the unavailability of federal systems that allowed the review of the draft plan, the public review period was extended to December 17, 2013. The extension notice was published in the *Federal Register* on November 1, 2013.

Park staff presented elements of the Restoration Plan/DEIS at three public meetings (in Fresno, Three Rivers, and Bishop, CA). Total attendance at the public meetings was 39. Park staff also presented elements of the Restoration Plan/DEIS at one meeting between Sierra National Forest staff and area tribes. The public meeting schedule was as follows:

- November 19, 2013: University of California-Merced, Fresno Center, Fresno, CA
- November 20, 2013: Three Rivers Arts Center, Three Rivers, CA
- November 21, 2013: Eastern Sierra Tri-county Fairgrounds, Bishop, CA

The NPS received public comment letters through the PEPC system, by fax, U.S. mail, and hand delivery. The full text of public comment letters received can be viewed on the project website at: http://parkplanning.nps.gov/aquatics. Personal information included with the comments (e.g., names and contact information) is redacted in the correspondence posted online to protect individuals' privacy. Information is included if the comment was submitted by agencies, tribes, businesses, and organizations.

During the public review period, the parks received 123 public comment letters: 116 from individuals; 4 from federal, state, county, or local governments; 1 from a tribe; and, 2 from recreational or conservation-related interest groups. The analysis of these letters identified 359 discrete comments, from which 48 concern statements were generated. The results of the public comment analysis process and the NPS responses to substantive public comments are provided in “Appendix E: Public Comment Concern/Response Report.”

Plan Revisions in Response to Public Review
The key revisions in this Restoration Plan/FEIS made in response to comments received during the public review of the draft plan and EIS are summarized below:

Chapter 1 – Purpose and Need — This chapter has been updated with clarified text for plan goals, objectives, and background. Figure 2 has been updated to reflect one additional year of data (2013). Figure 4 has been updated to reflect two additional years of data (2012 and 2013) and corrected to account for re-analysis of the survey data. Table 4 has been updated to include additional information obtained since 2013. The “Issues and Impact Topics” section has been updated to include information from the public review period.

Chapter 2 - Alternatives — This chapter has been updated to include clarified, revised or additional information in the following sections: “Elements Common to All Action Alternatives,” alternatives B (preferred), C, D, and “Alternatives Considered But Dismissed From Detailed Analysis.” The primary topics include site assessments, restoration of MYLFs, monitoring, fish disposal, and piscicide use (including methods for treatment and monitoring for invertebrates and water quality).

Specific proposed changes for fish eradication in alternative B (preferred) include:

- Total number of fish eradication waterbodies decreased from 87 to 85;
- Total acreage of fish eradication waterbodies decreased from 708 to 634;
- Total number of fish eradication stream miles decreased from 41 to 31;
- Number of physical treatment waterbodies increased from 49 to 52;
- Acreage of physical treatment waterbodies increased from 483 to 492;
- Number of physical treatment stream miles increased from 14 to 15;
- Number of piscicide treatment waterbodies decreased from 38 to 33;
- Acreage of piscicide treatment waterbodies decreased from 225 to 142;
- Number of piscicide treatment stream miles decreased from 27 to 16;
- Number of physical treatment lake basins increased from 15 to 17;
- Number of piscicide treatment basins decreased from 11 to 9;
- Physical treatment in two lakes in Swamp Basin was added. These lakes were proposed but not selected in the preliminary restoration of MYLFs project (NPS 2001), and were overlooked when the Restoration Plan/DEIS was developed;
- Treatment in the outlet of Horseshoe was changed from physical to piscicide, based on the basin site assessment completed in late summer 2013 (after the Restoration Plan/DEIS was developed);
- Piscicide use in Barrett, Slide, and Tablelands was removed after re-evaluating the habitat restoration needed in each area and determining that sufficient restoration could be achieved with a decrease in the proposed fish eradication area, which would allow for the project objectives to be met using physical fish eradication methods.

Specific changes for restoration of MYLFs in “Elements Common to All Action Alternatives” include (1) clarifying methods for frog translocations and antifungal treatment, and adding methods for capture-mark-recapture surveys, captive rearing and immunizations, salvaging drought-threatened populations, and garter snake relocation; and (2) increasing (from 40 to 55) the number of basins containing fishless habitat important for conservation of MYLFs and other native species. The methods added had not emerged as recommended restoration actions in the MYLF Conservation Strategy when the Restoration Plan/DEIS was published in 2013, but were developed and included in the now nearly-complete strategy, expected for publication in 2016 (FWS *in preparation*). Similarly, the 15 basins added were either identified in the strategy as frog conservation areas or were known to have been recently occupied by MYLFs, and thus all are good potential frog recovery sites.

Chapter 3 – Affected Environment — This chapter has been updated to clarify, revise, or add information.

Chapter 4 – Environmental Consequences — This chapter has been updated to clarify, revise, or add information in the following impact topics: special-status species, wildlife (vertebrate and invertebrate sections), wild and scenic rivers, water quality, wilderness character, health and safety, visitor experience and recreation, sustainability and long-term management, adverse impacts that could not be avoided, and irreversible or irretrievable commitment of resources.

Appendices — Select appendices have been updated to include clarified, revised, or additional information, including appendix A (Minimum Requirement Analysis); appendix B (Individual Fish Eradication Basin Maps); appendix C (Effects of Nonnative Fish); appendix E (Public Comment Concern / Response Report); appendix F: (Sensitive Species Lists); appendix G (Background Information and Effects of Rotenone on Ecological Health); appendix H (Human Health Risk Assessment); appendix I (Site Assessment Protocol and Example); appendix J (Life History of Mountain Yellow-Legged Frogs); appendix K (Wild and Scenic Rivers Act Section 7(a) determination); appendix L (U.S. Fish and Wildlife Service Consultations); appendix M (California Regional Water Quality Control Board Coordination); and appendix N (Piscicide Treatment Protocols).

Derivation of Issues and Impact Topics

Specific impact topics were developed for discussion and to allow comparison of the environmental consequences of each alternative. These impact topics were identified based on internal and external scoping; federal laws, regulations, and executive orders; NPS *Management Policies 2006*; site visits; and NPS knowledge of limited or easily impacted resources. A brief rationale for the selection of each impact topic is given below, as well as the rationale for dismissing specific topics from further consideration.

The resources which could be affected and the impacts that could occur are described in detail in "Chapter 3 - Affected Environment" and in "Chapter 4 - Environmental Consequences."

Issues and Impact Topics Selected for Detailed Analysis

In this section and the following section on "Impact Topics Dismissed from Further Analysis" the NPS analyzes potential impacts by considering the direct, indirect and cumulative effects of the proposed action on the environment, along with connected and cumulative actions. The NPS defines "no measurable effects" as minor or less effects; and "measurable" impacts as moderate or greater effects. "No measurable effect" is used by the NPS in determining if a categorical exclusion applies or if impact topics may be dismissed from further evaluation in an EA or EIS. The use of "no measurable effects" in this Restoration Plan/FEIS pertains to whether the NPS dismisses an impact topic from further detailed evaluation. In accordance with CEQ regulations at 1500.1(b), the NPS uses "no measurable effects" to determine whether impact topics can be dismissed from further evaluation is to concentrate on the issues that are truly significant to the action in question rather than amassing needless detail.

It was determined that there would be a measurable effect on key elements of high elevation aquatic ecosystems, including: special-status species (federally listed and species of management concern); wildlife; wild and scenic rivers; water quality; natural soundscapes; and wilderness character. In addition there could be effects on employee and public health and safety; and visitor experience and recreational opportunities (Table 5).

Table 5. Impact topics retained for further evaluation, and relevant associated laws, regulations and policies

Impact Topic	Reasons for Retaining Impact Topic	Relevant Laws, Regulations, and Policies
Special Status Species	This plan would affect two species of MYLFs that are currently federally listed as endangered under the ESA. Therefore, MYLFs will be further evaluated in this document. Several special status species or species of management concern occur in or near the proposed project areas, and may be affected by project activities. Species to be evaluated in this document include the Yosemite toad (*Anaxyrus [Bufo] canorus*), the Little Kern golden trout (*Oncorhynchus mykiss whitei*), and the Sierra Nevada bighorn sheep (*Ovis canadensis sierrae*). Other species of concern have been dismissed from further evaluation because they either do not occur in the project areas or the project would result in no measurable effects and are as described below under *Impact Topics Dismissed from Further Analysis.*	NPS *Organic Act*; *Endangered Species Act of 1973* (ESA) (16 USC 1531–1544; P.L. 93-205); NPS Management Polices 2006 (NPS 2006A); NPS-77 (NPS 1991**)** California Endangered Species Act (CESA; California Fish and Game Code, Sections 2050 et seq.)
Wildlife	Certain vertebrates and invertebrates would be measurably affected by nonnative fish eradication. For example, benthic macroinvertebrates would be affected by proposed piscicide use, and nontarget captures can occasionally occur when using gill nets. Therefore wildlife (certain vertebrates and invertebrates) will be further evaluated in this document.	NPS *Organic Act*; *NPS Management Policies 2006* (NPS 2006A); NPS-77 (NPS 1991)); Migratory Bird Treaty Act (16 USC § 703 et seq.)
Wild and Scenic Rivers	This plan includes project work that would occur near designated and eligible/suitable Wild and Scenic Rivers and may affect outstandingly remarkable values (ORVs). Therefore, Wild and Scenic Rivers will be further evaluated in this document.	*Wild and Scenic Rivers Act* (16 U.S.C 1271-1287, PL 90-542; *Clean Water Act of 1972* (33 USC 1251, P.L. 92-500); *NPS Management Policies 2006* (NPS 2006A)
Water Quality	Project activities and techniques considered in the alternatives could affect water quality. Therefore, water quality has been retained as an impact topic.	NPS *Organic Act*; *Clean Water Act of 1972* (33 USC 1251, P.L. 92-500); NPS-77 (NPS 1991)
Natural Soundscapes	The use of helicopters, stock and implementation of project activities is associated with and would create human-generated noise. Therefore, natural soundscapes have been included as an impact topic.	*NPS Management Policies 2006* (NPS 2006A); *Director's Order 47 Soundscape Preservation and Noise Management* (NPS 2000)

Impact Topic	Reasons for Retaining Impact Topic	Relevant Laws, Regulations, and Policies
Wilderness Character	This plan would occur within designated wilderness. Implementation of project activities could have both short-term and long-term adverse and beneficial effects on wilderness character. Therefore, wilderness character will be further evaluated in this document.	NPS *Organic Act*; *Wilderness Act of 1964*; The *California Wilderness Act of 1984* (PL 98-425, 98 Stat. 1619); *Omnibus Public Land Management Act of 2009*; *Director's Order 41* (NPS 2009B)*; Sequoia and Kings Canyon Management Directive 49* (NPS 2009C)
Health and Safety	The safety of park visitors and employees could be affected by components described in this plan. Therefore, health and safety will be addressed as an impact topic in this document.	*NPS Management Policies* 2006 (NPS 2006A)
Visitor Experience and Recreational Opportunities	Elements considered in this plan would have an effect on visitor experience and recreational opportunities. Recreational opportunities, such as angling, could be eliminated from proposed restoration sites and replaced with other opportunities, such as opportunities to view wildlife characteristic of pristine lakes. Therefore, visitor experience and recreational opportunities will be further evaluated in this document.	NPS *Organic Act*; NPS *Management Policies* 2006 (NPS 2006A); NPS-77 (NPS 1991); the *Redwood Act*, 1978

Impact Topics Dismissed from Further Analysis

Individual Special-Status Species and Species of Management Concern Ruled out from Further Analysis

Section 7 of the ESA requires all federal agencies to consult with the FWS to ensure that any action authorized, funded or carried out by the agency does not jeopardize the continued existence of listed species or critical habitats. NPS biologists reviewed the lists of federally listed and state-listed species, and species of management concern, to determine which species could potentially be affected by implementation of the proposed Restoration Plan/FEIS. Certain species were retained for further analysis and are identified in Table 5; a biological opinion is included in appendix L. Other species were dismissed from further analysis because they either do not occur within the project area, or project implementation would result in less than minor effects, or is not likely to adversely affect these species (see appendix F).

There would be potential for birds with special status or species of management concern to occasionally be present in the project area. These species are the bald eagle (*Haliaeetus leucocephalus*), peregrine falcon (*Falco peregrinus*), and California spotted owl (*Strix occidentalis occidentalis*). None are federally listed. The bald eagle and peregrine falcon are state listed as endangered and/or fully protected. The California spotted owl is a species of concern for the USFS, CDFW, Bureau of Land Management (BLM), American Bird Conservancy (ABC), and International Union for Conservation of Nature (IUCN). While these species may be present in or near the project area, if so it is likely they are present only for short periods of time (i.e. an occasional flyover or foraging session). There are no known nesting sites near any of the proposed restoration areas for any of these species, and the project would not result in the removal of suitable habitat, thus there would be no effect to habitat. Disposal of removed nonnative fish could slightly benefit the bald eagle, which feeds on fish carcasses. If the selected alternative results in the use of piscicides, studies have shown that animals can feed on these carcasses with minimal effects (EPA

2007A; see Appendices G and H). Further, although commonly thought to be piscivores, bald eagles have a more generalist diet (Sibley 2003). Therefore, bald eagles are not likely to be measurably affected by this project. The peregrine and spotted owl would not be affected by this project; therefore, these species have been dismissed from further analysis.

Most of the project area occurs at elevations above the normal range of the Pacific fisher (*Pekania* [=*Martes*] *pennanti*), though occasionally fishers may move through the area. The fisher was proposed for listing as a threatened species under the ESA (FWS 2014B), but the listing was withdrawn because its current status does not meet the statutory definition of an endangered or threatened species (FWS 2016). Since nearly all of the proposed restoration areas occur at higher elevations than its habitat, it is highly unlikely that crew presence would disturb this animal. Due to the unlikely presence of the species and the negligible impacts from human action, this species has been dismissed from further analysis.

SEKI is home to 150 vascular plant species of park management concern, of which 83 are designated as potentially sensitive species based on California Native Plant Society (CNPS) rare plant rankings (Huber et al., 2013). Of these, 52 have the potential to occur within the proposed project area. There are no federally designated plants of concern in SEKI, however, in 2011, the FWS announced a 12-month finding on a petition to list whitebark pine (*Pinus albicaulis*) as threatened or endangered under the Endangered Species Act. The FWS decided that listing was warranted due to the fact that it faces an “imminent” risk of extinction. However, listing whitebark pine as threatened or endangered was precluded by higher priority actions. While the whitebark pine occurs in the project area, there would be no effect on this species from any project activities. The only state listed rare plant known to occur in SEKI is Tompkins sedge (*Carex tompkinsii*), which reaches the southern edge of its distribution in the South Fork of the Kings River. Although suitable habitat for this species may be found in the lower reaches of the Crescent Creek drainage of Sequoia National Park, it is not known to occur within the proposed project area. In the higher elevations, the state listed Mono milkvetch (*Astragalus monoensis*) occurs east of the Sierra crest in Mono and Inyo Counties; however, it is not expected to occur in the habitat proposed for treatment. Because none of these species of concern are expected to occur in the project area, and those recognized by the CNPS would be surveyed for prior to any actions, and any potential impacts mitigated, special status plants were dismissed from further analysis.

Individual Wildlife Species

NEPA requires examination of measurable impacts to wildlife species that are not designated as special status species or species of management concern. NPS biologists reviewed the wildlife species that have the potential to occur in the project area, in order to determine which species could potentially be affected by implementation of the proposed Restoration Plan/FEIS. Certain species were retained for further analysis and are described in chapter 3, Affected Environment, Wildlife.

The following species were dismissed from further analysis because they are only occasionally or rarely observed within the project area, or project implementation would result in less than minor effects, or is not likely to adversely affect these species.

Many vertebrates occasionally feed in or near high elevation aquatic ecosystems and thus may be present in the project area. The most common of these species include the Mount Lyell salamander (*Hydromantes platycephalus*), mallard (*Anas platyrhynchos*), dark-eyed junco (*Junco hyemalis*), common raven (*Corvus corax*), yellow-bellied marmot (*Marmota flaviventris*), pika (*Ochotona princeps*), mule deer (*Odocoileus hemionus*), lodgepole chipmunk (*Tamias speciosus*), deer mouse (*Peromyscus maniculatus*), short-tailed weasel (*Mustela erminea*), long-tailed weasel (*Mustela frenata*) and American black bear (*Ursus americanus*). However, because these species are either: (1) only occasionally or rarely observed in the project area (e.g., Mt. Lyell salamander), or (2) widely distributed and only minimally associated with aquatic habitats, it is not likely that the proposed plan would have a measurable impact on these wildlife species; therefore, these species have been dismissed from further analysis.

Wetlands and Riparian Habitat (meadows and shorelines adjacent to lakes, ponds, streams and marshes)

The character and function of wetlands and riparian habitat would not be changed from the project work. While blasting may occur if alternative C is selected, the resulting effects would not displace habitat or create ponds, or change the character or function of the stream habitat or ecology, or result in the placement of "fill materials." There is the potential that work from this project would cause localized adverse effects from crews walking on the shorelines of lakes, ponds, streams, and marshes, which could affect riparian habitat slightly by trampling vegetation and loosening soils. However, the impact to riparian habitat would be minimal because crew sizes are small, creating impacts similar to the average backpacking party. In addition, crews would be instructed to avoid particularly sensitive areas. There could be slight effects on meadows from the potential use of stock. Stock would follow the NPS minimum impact requirements and Stock Use Regulations, and would be used only for the transport of supplies to and from the project locations at the start and end of the project work. Thus the overall impacts would be less than minor. Effects on wetland fauna (vertebrates and invertebrates) and water quality are evaluated within the wildlife and water quality sections respectively.

Air Quality and Greenhouse Gas Emissions

The 1977 amendment to the *Clean Air Act of 1963* (42 U.S.C. 7401 et seq., P.L 88-206) requires federal land managers to protect park air quality. Sequoia and Kings Canyon National Parks were designated Class I under the 1970 *Clean Air Act*, as amended. A Class I area is subject to the most stringent regulations of any designation. Further, the 1970 *Clean Air Act* provides the federal land manager (the Assistant Secretary for Fish and Wildlife and Parks and the Park Superintendent) with an affirmative responsibility to protect the parks' air-quality-related values (including visibility, plants, animals, soils, water quality, cultural and historic resources and objects, and visitor health) from adverse air-pollution impacts. Section 118 of the *Clean Air Act* requires the parks to meet all federal, state, and local air-pollution standards.

The proposed project is located within the San Joaquin Valley Air Pollution Control District (SJV Air District). Most of the air pollutants within the parks originate outside the park boundaries. Non-point sources continue to be the major contributor of air pollutants in the SJV Air District, including cars, trucks, farm equipment, and other agricultural activities. According to 2006 air quality monitoring data, the main contributor in the park to the criteria air pollutants (CAPs) and greenhouse gases (GHGs) is transportation, contributing 66%. The largest portion of this is from visitor vehicle miles travelled.

GHGs contribute to climate change on a global scale. Naturally occurring greenhouse gases include carbon dioxide, methane, nitrogen oxide, and water vapor. Human activities (e.g., fuel combustion and waste generation) lead to increased concentrations of these gases (except water vapor) in the atmosphere. While GHGs contribute to climate change on a global scale, the impacts of CAPs are often local and regional in nature.

In an effort to reduce air-pollution sources within the park, the park has formed a partnership with the EPA to collaborate on controlling greenhouse gases and climate change through the Climate-Friendly Parks Program. As part of this program, the park has developed an action plan to reduce CAPs and GHGs. Transportation strategies described in the plan relative to the proposed project include improving vehicle efficiency and reducing idling (*Climate-Friendly Parks: Sequoia and Kings Canyon National Parks*, NPS 2008B).

Should any of the action alternatives be selected, local air quality would be temporarily affected, primarily by the use of helicopters to transport materials. However, while these activities would result in a slight degradation of air quality in the project area; the emissions from the project activities would not be likely to exceed National Ambient Air Quality Standards. The impacts would last only as long as helicopter flights occurred, and would result in local, short-term, negligible adverse impacts on air quality.

Some project alternatives include the proposed use of commercial rotenone liquid formulations. Piscicides used for the treatment as part of the proposed alternative could result in a slight odor in the proposed project area. Although access nearby the project area would not be restricted during implementation of the project, access to the treatment area itself would be restricted, and thus potential odors would likely only affect workers involved in the treatment process and be limited to the project area for short periods of time - up to several days depending on air and water temperatures and wind direction (Finlayson et al. 2000). The applications would be site specific and occur over short durations (4 to 6 hours), and would result in negligible effects to the air quality on a localized basis. Therefore, air quality was dismissed as an impact topic.

Topography, Geology and Soils
Soil and water chemistry characteristics in the Sierra Nevada are largely geologically controlled. Because the Sierra Nevada is underlain by mostly granitic rocks, soils that develop from these foundations are thin and rocky with low nutrient capital (fertility), especially at higher elevations. There are some areas of metamorphic rock such as schist and marble within the project area. Soils in most of these areas are shallow to non-existent and weakly developed (Barbour et al. 2007).

Electrofishing and aquatic invertebrate sampling would involve crews temporarily disturbing streambeds and lake shorelines, which would alter small amounts of loose material. Disturbance of fluvial sediments and rock material is expected to be within the range of natural variability, such as in the case of spring run-off that increases turbidity. Disturbance of soils associated with wetland areas are expected to be minimal because crew sizes are small, creating impacts similar to the average backpacking party. Proposed project activities, such as crews accessing and working in the project areas and activities associated with camping during project work, could impact soils in localized areas. Typical crew size would consist of two to four members. Each restoration site would be visited approximately six times from late June to early October. Sites would be occupied for up to 10 days per visit. To ensure successful eradication/restoration, sites could be visited annually for up to 3 to 5 consecutive years. To minimize impacts to soils, crews would adhere to “Leave No Trace” principles, reducing the potential for adverse impacts to soils. Because none of the alternatives would have measurable effects on topography, geology or soils, these topics have been dismissed from further analysis.

Upland Vegetation
The upland vegetation associated with the treatment sites varies from montane forests and woodlands to subalpine and alpine sites. The montane forests are dominated by ponderosa pine (*Pinus ponderosa*), Jeffrey pine (*Pinus jeffreyi*), sugar pine (*Pinus lambertiana*), incense cedar (*Calocedrus decurrens*), white fir (*Abies concolor*) and giant sequoia (*Sequoiadendron giganteum*). The understory can be open or contain patches of bush chinquapin (*Chrysolepis sempervirens*), various species of California lilac (*Ceanothus* sp.), gooseberries (*Ribes* sp.) and other shrubs.

Within the upper montane and subalpine zones, the forests are dominated by Jeffrey pine, red fir (*Abies magnifica*), western white pine (*Pinus monticola*), western juniper (*Juniperus occidentalis*), foxtail pine (*Pinus balfouriana*), lodgepole pine (*Pinus contorta*) and whitebark pine (*Pinus albicaulis*). Here the understory tends to be more open than in the montane zone, but some shrubs like currants (*Ribes* sp.) are present. These elevations also contain open areas occupied by green-leaf manzanita (*Arctostaphylos patula*), rock spirea (*Holodiscus microphyllus),* currants, and/or grass (*Stipa* sp.).

The vegetation of the alpine zone is very sparse, the landscape is very rocky and the growing season is short. Major habitats include rocky slabs and boulders, scree and alpine fell fields. Common vegetation includes buckwheat (*Eriogonum* spp.) and patches of threadleaf sedge (*Carex filifolia*).

Proposed project activities, such as crews accessing and working in the project areas and activities associated with camping during project work, could impact vegetation in localized patches. Typical crew size would consist of two to three members. Each restoration area (which includes the campsite and restoration waterbodies) would be visited up to seven times between June and September; sites would be occupied for up to 10 days per visit. To ensure successful eradication/restoration, most sites would be visited annually for 5 to 7 consecutive years, and some sites would be visited annually for up to 10 consecutive years. To minimize impacts to vegetation, crews would adhere to "Leave No Trace" principles. There is the potential for introducing nonnative plants via shoes, clothing or equipment to the project areas, however, park standards for managing invasive species requires crews to inspect and clean items thoroughly prior to entering project areas which minimizes this risk of introducing nonnative plant materials. Crews would practice "Leave No Trace" principles to minimize ground disturbance in the camp areas and around the restoration lakes and streams, and there would be no measureable effects to upland vegetation, therefore this impact topic is dismissed from further analysis.

Impacts to vegetation associated with riparian habitat are included under wetlands and riparian habitat earlier in this section.

Scenic Resources

NPS *Management Policies 2006* states that scenic views and visual resources are considered highly valued associated characteristics. SEKI was set aside as national parks and then as designated wilderness partly for the remote and mountainous terrain. Granite peaks rising in excess of 14,000 ft (4,300 m) adjacent to deep glacially carved canyons define SEKI's mountainous landscape. This Restoration Plan/FEIS would not have any measurable effect on scenic resources; therefore, this topic has been dismissed from further analysis.

Historic Structures, Archeological, Ethnographic and Cultural Landscape Resources

Approximately 6% (51,000 ac/20,639 ha) of SEKI has been systematically surveyed for the presence of cultural resources, both historic and prehistoric, including the subalpine/alpine regions. By definition, historic sites are at least 50 years old and prehistoric sites are by definition Native American in nature. The oldest Native American artifacts (projectile points) recovered in the parks are approximately 5,000 to 7,000 years old. Cultural artifacts provide evidence of prehistoric, ethnographic, culturally important landscapes, and historic use of park areas. Reported high country resource sites have been mapped by the Cultural Resources Office. The proposed project sites would be reviewed with the Cultural Resources Office prior to entering into an area. In the event that crews inadvertently find cultural artifacts at a restoration site, the crew would stay out of the discovery site and communicate information to the Cultural Resources Office as required by the parks' inadvertent discovery protocol.

This Restoration Plan/FEIS would not have any measurable effect on known cultural resource sites or potential sites, or on museum collections; therefore, cultural resources have been dismissed from further analysis.

Socioeconomic Environment and Growth Inducing Impacts

There may be a minor influence on socioeconomics associated with the reduction in some angling opportunities; however, the number of fishing lakes available for recreational use would remain plentiful within the parks and the number of visitors accessing the park to fish is not expected to decrease. Consequently, actions considered in this proposed project would have negligible impacts on the socioeconomic environment; therefore, this topic has been dismissed from further analysis. The project would not create opportunities to foster economic or population growth, or remove an obstacle to growth; therefore, this topic has been dismissed from further analysis.

Indian Trust Resources

Secretarial Order 3175: Identification, Conservation and Protection of Indian Trust Assets requires that any anticipated impacts on Indian trust resources from a proposed project or action by Department of the Interior agencies be explicitly addressed in environmental documents. The lands comprising Sequoia and Kings Canyon National Parks are not held in trust by the Secretary of the Interior for the benefit of Indians or because of their status as Indians; therefore, this topic has been dismissed from further analysis.

Environmental Justice

Executive Order 12898: *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations* (59 FR 7629), requires all agencies to incorporate environmental justice into their missions by identifying and addressing disproportionately high and adverse human health or environmental effects of their programs and policies on minorities and low-income populations or communities. No alternative under consideration meets these criteria; therefore, this topic has been dismissed from further analysis.

Prime Farmland

In 1980, the CEQ (40 CFR 1500) directed federal agencies to assess the effects of their actions on farmland soils classified as prime or unique by the U.S. Department of Agriculture, Natural Resources Conservation Service. Prime farmland soil produces general crops such as common foods, forage, fiber and oil seed. Unique farmland produces specialty crops such as fruits, vegetables and nuts. There are no prime or unique farmlands within the project area; therefore, this topic is dismissed from further analysis.

Biosphere Reserves, Ecologically Critical Areas, Other Unique Areas

In 1976, Sequoia and Kings Canyon National Parks were designated an international biosphere reserve by the United Nations Educational, Scientific, and Cultural Organization (UNESCO) under the direction of the Man and the Biosphere Program. According to *NPS Management Policies 2006*: “Biosphere Reserves are sites that are part of a world-wide network of natural reserves recognized for their roles in conserving genetic resources; facilitating long-term research and monitoring; and encouraging education, training, and the demonstration of sustainable resource use. . .” The proposed Restoration Plan/FEIS would not threaten the associated qualities and resources that make SEKI significant, nor would it affect SEKI’s status as an international biosphere reserve. Rather, it would benefit those resources for which SEKI became a Biosphere Reserve. These topics are therefore dismissed from further analysis.

Compliance with Federal Accessibility Laws

Section 504 of the *Rehabilitation Act of 1973* (29 USC 794 P.L. 93-112) and the *Architectural Barriers Act of 1968* (42 USC 4151) require that programs be reviewed for accessibility and for federal services. This Restoration Plan/FEIS would not have any effect on federal accessibility laws; therefore, this topic has been dismissed from further analysis.

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CHAPTER 2 - ALTERNATIVES

INTRODUCTION

This chapter describes the range of alternatives that were considered that could potentially meet the objectives of this Restoration Plan/FEIS. These alternatives were developed through an interdisciplinary planning process that included discussions among NPS subject matter experts, agency officials, partner agencies, scientists and comments received during public scoping. The alternatives for this plan were assessed using a minimum requirement analysis (appendix A) to determine if the actions included in the Restoration Plan/FEIS are the minimum required to protect wilderness character and resources.

Background
A substantial body of research and management directly influenced the actions proposed in this Restoration Plan/FEIS. These data include (1) an inventory of lakes conducted from 1997 to 2002 that surveyed approximately 3,250 waterbodies for fish presence, amphibian composition, and general habitat features (Knapp R., unpublished data); (2) studies, surveys, and observations of amphibians and/or fish from the 1970s to the present; (3) 12 years of aquatic restoration efforts; and (4) complete site assessments of all of the proposed fish eradication basins. This work has allowed an in-depth understanding of high elevation aquatic ecosystems in SEKI, and provided high-quality information from which to propose a park-scale restoration plan. This information was used to derive the following.

First, since recovery of federally endangered MYLFs is a conservation priority, the initial step was to capture the locations where MYLF populations still occur or recently died out. Fishless areas targeted for potential MYLF conservation actions are also important for other native species (Table 7 and Figure 5). Within and near these areas, sites were located where fish eradication is feasible, which would allow existing MYLF populations to grow, and recently extirpated populations to be reestablished, in restored habitat. Next, park staff determined how many sites from which fish could be successfully eradicated in 25 to 35 years. Using this estimate, several fish eradication areas were selected in each of the three MYLF genetic clades present in SEKI. The NPS also considered popular fishing destinations and attempted to select sites to minimize impacts to recreational fishing. This methodology resulted in a proposal which, if successful, would include a network of restored aquatic habitats for MYLFs and other native species at the basin scale.

A total of 11 action alternatives and the no action alternative were originally identified in the Restoration Plan/DEIS (NPS 2013A). A twelfth action alternative, using drought conditions to allow for the exclusive use of physical fish removal methods, was suggested during public comment of the Restoration Plan/DEIS and was also considered. Of these, nine action alternatives were dismissed from further consideration as described later in this chapter. Three action alternatives and the no action alternative are carried forward for further analysis. The environmentally preferred alternative is identified later in this chapter. Table 16, a summary table comparing the components of the alternatives, is presented at the end of this chapter.

Alternative A (the no action alternative) describes current management of high elevation aquatic ecosystems in SEKI and provides a baseline for comparison against the action alternatives. Alternatives B, C and D (action alternatives) describe a range of reasonable and feasible approaches to meet the purpose and need for action and to achieve the plan objectives described in chapter 1.

ALTERNATIVE A: NO ACTION

Under the no action alternative, the existing high elevation aquatic ecosystem restoration effort for 25 waterbodies within SEKI would be completed, maintained and monitored, and 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 to the extent possible without fish removal. Research on native species, ecological processes and their stressors would continue in accordance with NPS policy.

General Aquatic Ecosystem Management
Current management of high elevation aquatic ecosystems within SEKI includes an active program of research, monitoring and restoration.

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 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 on a regular basis include water quality and populations of amphibian and reptiles associated with restoration and research sites.

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

Ongoing Aquatic Ecosystem Restoration
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 selected individual waterbodies 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 waterbodies, (2) measure benefits to MYLFs and (3) gain the knowledge needed to develop a comprehensive restoration program.

From 2001 to 2011, SEKI staff fully eradicated nonnative fish from eight waterbodies (and associated streams) and nearly eradicated nonnative fish from three additional waterbodies (and associated streams). The three waterbodies where fish were nearly eradicated had insufficient barriers (small non-vertical natural cascades) that have allowed fish to recolonize these areas each summer. Habitat below these three waterbodies is proposed for nonnative fish eradication in this Restoration Plan/FEIS, which would allow these waterbodies to be completed and thus retained as fishless habitat.

From 2009 to 2012, nonnative fish eradications were initiated in 12 additional waterbodies (NPS 2009A). Eradications are complete in five of these waterbodies (initiated in 2009), and nearly complete in seven of these waterbodies (initiated in 2009, 2010 and 2012). Eradication work in all of these 12 waterbodies is expected to be completed by 2017.

These 25 waterbodies (Table 6) include all of the sites previously approved for nonnative fish eradication (NPS 2001, 2009A). They comprise 4% of the 575 high elevation waterbodies known to contain self-sustaining nonnative trout populations before this work was initiated (Knapp R., unpublished data). For these 25 waterbodies, researchers eradicated fish in two waterbodies by 1999; the NPS eradicated fish in 13 waterbodies by 2015; and the NPS expects to eradicate fish in seven waterbodies by 2017. The remaining three waterbodies would be eradicated of fish by about 2020 if proposed habitat below them is selected for fish eradication in this Restoration Plan/FEIS. Under the no action alternative, monitoring and conservation of native species would continue for the foreseeable future in all 25 waterbodies. After these 25 waterbodies are eradicated of fish, self-sustaining nonnative trout populations would remain in 550 high elevation park waterbodies.

Table 6. Number of waterbodies and stream miles per basin previously approved for nonnative fish eradication in SEKI using physical treatments

Basin	# Lakes	Area (ac)	# Ponds	Area (ac)	Stream (mi)
Nonnative Fish Eradication Completed or In-Progress					
Amphitheater	2	36.82	1	0.66	0.34
Kern Point*	1	25.15	1	1.23	0.15
LeConte Canyon*	2	7.32	1	1.26	1.00
Pinchot*	1	9.35	0	0	0.00
Sixty Lake¥	5	36.47	6	7.71	1.04
Upper Basin*	2	19.53	0	0.00	0.80
Upper Bubbs†	3	16.23	0	0.00	0.35
=completed; ¥=2 lakes and 3 ponds completed; †=2 lakes completed (as of 2015)					
Grand Total	**16**	**150.88**	**9**	**10.86**	**3.68**

Ongoing Aquatic Ecosystem Research

SEKI annually collaborates with agency and academic scientists to address critical information needs for management of aquatic ecosystems. One critical need is to continue studies of the effects of amphibian chytrid fungus on amphibian populations and aquatic ecosystems. Chytridiomycosis, the disease caused by amphibian chytrid fungus, has infected nearly every MYLF population in SEKI. Only a few populations remain uninfected. In YOSE, every MYLF population is infected by amphibian chytrid fungus. These outbreaks have reduced the abundance and distribution of MYLFs in SEKI and YOSE to very low levels, including the extirpation of entire populations from many basins in SEKI. Research on chytrid fungus is continuing with a goal of obtaining a better understanding of how to (1) mitigate its effects and (2) conserve native species in an amphibian chytrid-filled landscape. Additional information would likely include understanding the effects of climate change, other invasive species, and air pollution on aquatic ecosystems in order to mitigate these effects. These efforts would continue under this alternative.

Aquatic Ecosystem Conservation

Under this alternative, conservation of native species and ecosystem processes would continue to occur in high elevation aquatic ecosystems throughout SEKI, particularly in basins with fishless habitat important for MYLF conservation. Based on current knowledge, 55 basins contain fishless habitat important for conservation of MYLFs and other native species (Table 7 and Figure 6). Table 7 lists these basins by their respective location within each unique MYLF genetic clade. Fishless habitat within these basins includes lakes, ponds, streams and associated wetlands. Four of these 55 basins previously contained lakes with nonnative fish that were eradicated in the last decade or are close to being eradicated (Kern Point, LeConte Canyon, Pinchot, Upper Basin). MYLF restoration actions are most likely to be implemented in these areas, but are not restricted solely to these areas. Isolated patches of fishless habitat occur in additional basins and would be similarly managed to conserve native species and ecosystem processes.

Table 7. List of basins containing fishless habitat important for conservation of native species

San Joaquin/Kings MYLF Clade	Kings/Kern MYLF Clade	Southern Kern MYLF Clade	Unknown MYLF Clade
Black Divide	Cirque Crest	Funston Creek	Crescent
Darwin Bench	Crabtree Creek	Crytes*	Hockett
Devils Crag	East Lake Reflection	Laurel*	Pinto Lake
Glacier Creek	Ionian		Blossom*
Gorge of Despair	Kaweah Basin		Tablelands*
Granite Pass	Kern Point‡		
Kennedy Canyon	Kern Ridge		
LeConte Canyon‡	Lewis Lake		
LeConte Divide	North Finger Peak		
Observation	North Martha		
Palisade Creek	Pinchot‡		
South Fork Cartridge Creek	Red Spur		
Swamp Lakes	Upper Basin		
West Monarch	Tyndall Creek		
Amphitheater‡*	Wallace Creek		
Barrett*	Whitney		
Dusy*	Woods		
Horseshoe*	Wynne		
McGee*	Brewer*		
Rambaud*	East Wright*		
Slide*	Milestone*		
Upper Evolution*	Sixty Lake‡*		
	Upper Bubbs‡*		
	Upper Kern*		
	Vidette*		

** = Basins containing both fishless waters and fish-containing waters that are proposed for additional restoration in the FEIS. Crescent Creek is also a proposed restoration area in this FEIS, but currently does not contain any fishless habitat.*
‡ = Basins in which fish eradication is either completed or in-progress for previously approved waterbodies (NPS 2001)

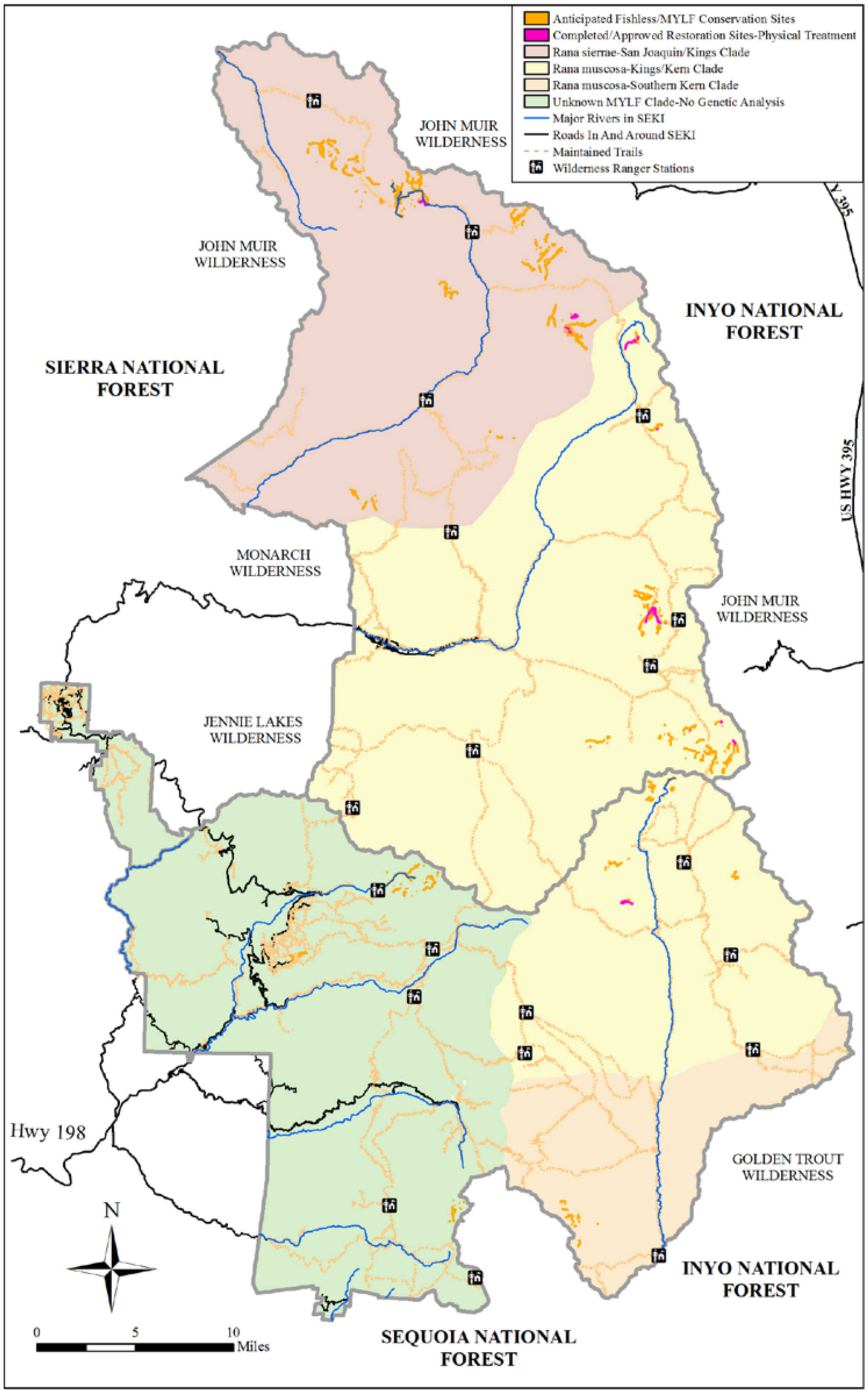

Figure 5. Map of fishless areas

Fishless areas are shown in orange, with habitat important for conservation of MYLFs and other native species, located in or near basins where physical or piscicide fish eradication is either ongoing or proposed in this Restoration Plan/FEIS. Recently completed or in-progress fish eradication sites are highlighted in pink.

ELEMENTS COMMON TO ALL ACTION ALTERNATIVES

The following actions would be adopted under action alternatives B, C and D. Actions are described in relationship to the objectives of this Restoration Plan/FEIS, which are described in chapter 1.

Basin Selection
The following selection process was used to determine which basins and individual waterbodies should be proposed for aquatic ecosystem restoration in this Restoration Plan/FEIS. Initial basin/site selections were based on review of sites proposed for fish eradication (but not selected) in the preliminary restoration project (NPS 2001), examination of maps, staff familiarity with the parks, and discussions with scientists. A number of criteria were then developed and used to identify project sites that would be feasible for nonnative fish eradication and would have the best potential for success while providing for crew safety (Table 8). For example, all proposed treatment sites would be located at the upstream ends of each basin so that no fish would remain above each treatment area. Second, all proposed sites also would have a natural cascade at the downstream end of the treatment area that would act as a fish barrier and prevent fish remaining in untreated areas downstream from recolonizing the treatment area. Third, all proposed sites would be safely accessible by crews on foot and by helicopter or stock for transport of equipment and supplies. Fourth, the total number of fish eradication waterbodies targeted could be completed in the 25 to 35 year time frame of this project. While conservation of MYLFs and native ecosystems is identified as the highest priority consideration, SEKI also would attempt to maintain recreational fishing opportunities where those opportunities do not compromise the recovery of native species.

When these criteria were applied to the approximately 550 candidate waterbodies containing nonnative fish, a total of 85 waterbodies (31 lakes, 49 ponds, and 5 marshes; total of 634 ac/257 ha) and 31 mi (50 km) of streams in 21 basins were proposed for fish eradication in the Restoration Plan/FEIS. These 85 waterbodies and 31 stream miles represent the maximum amount of habitat that would be restored under any of the action alternatives. Figure 6 shows the location of these basins within the major watersheds; and Table 9, Table 10, and Table 11 list the sites selected.

Table 8 shows the basin selection criteria used to determine which waterbodies should be considered for proposed aquatic ecosystem restoration:

- First, waterbodies possessing the characteristics listed under “Rule-out” were removed from consideration for additional nonnative fish eradication.
- Second, for all remaining waterbodies, those that possessed the characteristics described in the left column under “Other Consideration Factors” were identified as higher priority for additional nonnative fish eradication because their inclusion helped achieve multiple project objectives. Waterbodies from this group that fell under the right column were identified as lower priority for additional nonnative fish eradication because their inclusion helped achieve fewer project objectives.
- Third, from the group of waterbodies identified as higher priority for additional nonnative fish eradication, waterbodies were selected from across the parks to ensure the proposed sites would restore and conserve native species, genetic diversity and ecosystem processes in areas encompassing the geographic and elevational diversity contained within the parks.

Table 8. Basin Selection Criteria

Favorable	**Rule-out**
Elevation is between 6,000 and 12,000 ft.	Elevation under 6,000 ft or above 12,000 ft. Lake basins in SEKI typically do not occur outside of these elevations.
Adequate downstream barrier (large waterfall or long, steep cascade) exists naturally, or the stream could be altered by blasting to create a vertical fish barrier, which would prevent fish from recolonizing restoration area. Barrier potential would be assessed prior to the onset of restoration.	No adequate downstream fish barrier exists naturally and there is no potential to create a barrier by blasting. Fish are observed breaching all possible barriers and would likely continue breaching even after blasting.
Fish eradication is feasible from a logistical standpoint. Habitat structure would allow fish eradication without extreme difficulty, and site can be safely accessed by field crews.	Fish eradication is considered infeasible from a logistical standpoint. Habitat structure is so complex that it would be extremely difficult to eradicate fish, and/or site cannot be safely accessed by field crews.
Crew presence unlikely to jeopardize the existence of known threatened or endangered plant or wildlife species.	Crew presence could jeopardize the existence of known threatened or endangered plant or wildlife species.
Evidence of current or recent populations within natural distribution of MYLFs (includes sites where frogs recently died out due to disease).	There is no evidence of current or past MYLF populations (removal of fish would also benefit other native species).
Other Consideration Factors	
Achieves More Objectives	**Achieves Fewer Objectives**
Restores/conserves genetic diversity of MYLFs within SEKI – several sites restored within each of three major genetic groups.	Total number of restoration sites is imbalanced with respect to genetic diversity of MYLFs within SEKI.
Restores/conserves spatial representation MYLFs within SEKI – sites restored across park latitudes and longitudes.	Total number of restoration sites is imbalanced with respect to historic representation of MYLFs within SEKI.
Groupings of waterways appropriate for treatment. For basins in which some fish lakes would remain, restoration lakes are at top of basin. Several entire basins are restored, spread across SEKI.	Groups of waterways not considered appropriate for treatment. For basins in which some fish lakes would remain, restoration lakes are at middle or bottom of basin. No entire basins are restored in SEKI.
For individual lake selection, recreational fishing value of lake is medium to low – not a very popular or trophy fishery. For the overall project, fishing opportunities within SEKI continue to exist that satisfy a range of visitor values, including multiple lakes: 1) near trailheads for easy access; 2) in remote basins for solitude; 3) having large fish for a trophy experience; 4) having many fish for a high-catch experience.	For individual lake selection, recreational fishing value of lake is high – a very popular or trophy fishery. For the overall project, multiple fish lakes within each of the following categories do not continue to exist within SEKI: 1) near trailheads for easy access; 2) in remote basins for solitude; 3) having large fish for a trophy experience; 4) having many fish for a high-catch experience.
Other known threats not an issue.	Other threats make site less desirable. For example, considering piscicide use in areas close to human populations.

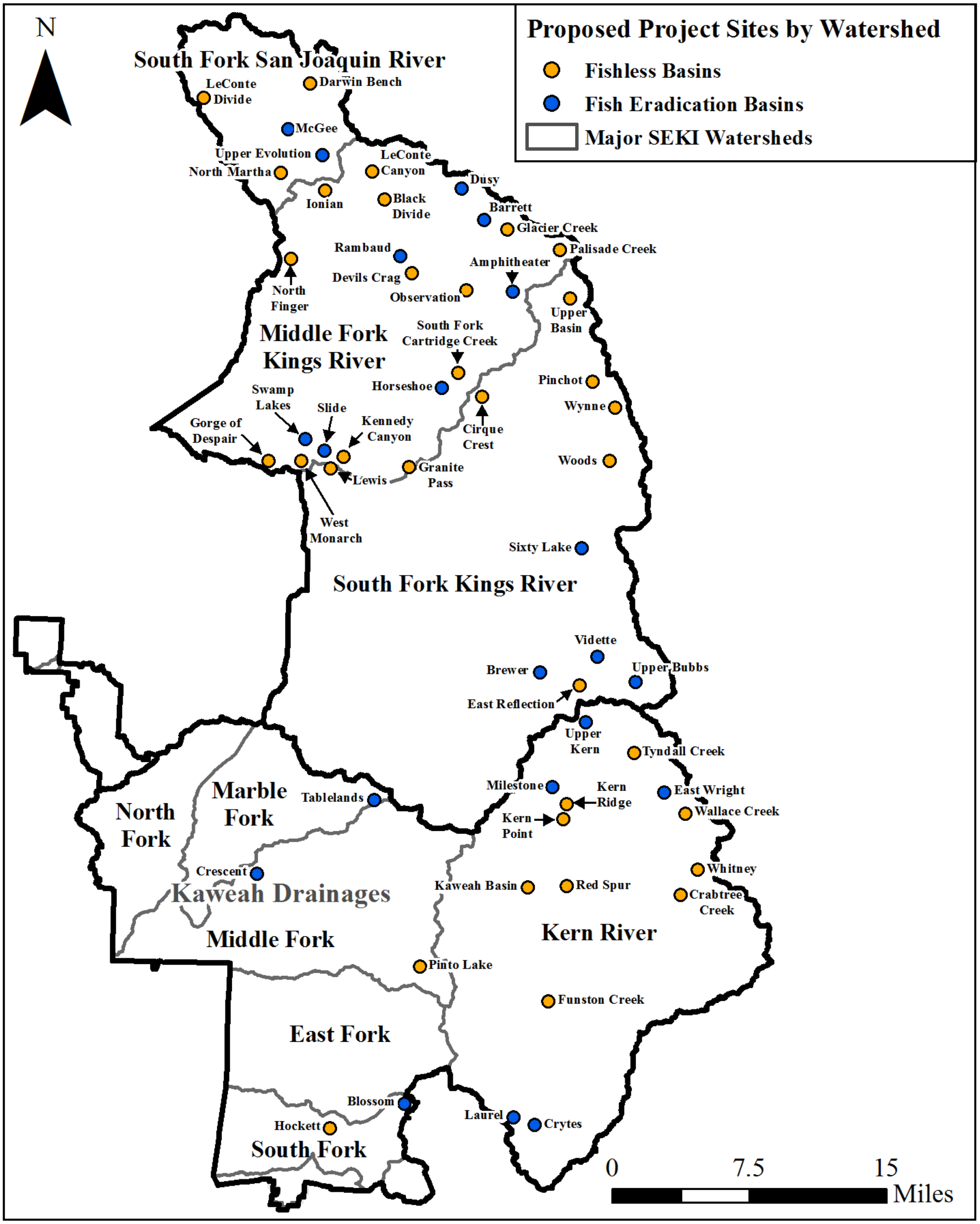

Figure 6. Map showing locations of proposed aquatic ecosystem restoration sites

Figure 6 shows basins with only fishless conservation waterbodies in orange, and basins with proposed fish eradication waterbodies in blue, all of which (except Crescent) also contain fishless conservation waterbodies.

Table 9 lists all basins proposed for additional nonnative fish eradication in this Restoration Plan/FEIS, including the number of lakes (L) and ponds (P), stream miles (S) and treatment method (Physical, Piscicide) per basin under each alternative. Not included in this table are five known fish-containing marsh areas (totaling 32 ac/13 ha) that are also proposed for fish eradication in three basins (Tablelands, Crytes, and Laurel).

Table 9. Basins and waterbodies proposed for nonnative fish eradication under alternatives B, C and D

Basins with New Sites for Fish Removal	Alternative B						Alternative C			Alternative D		
	Physical			Piscicide			Physical			Piscicide		
	L	P	S	L	P	S	L	P	S	L	P	S
Amphitheater	0	0	0	1	2	2.16	0	0	0	1	2	2.16
Barrett	3	1	0.87	0	0	0.00	3	1	0.87	3	1	0.87
Blossom	2	2	0.64	0	0	0	2	2	0.64	2	2	0.64
Brewer	0	1	0.52	0	0	0	0	1	0.52	0	1	0.52
Crescent	0	0	0	0	0	1.58	0	0	0	0	0	1.58
Crytes	2	1	0.02	0	0	1.99	2	1	0.02	2	1	2.00
Dusy	1	2	0.69	0	0	0	1	2	0.69	1	2	0.69
East Wright	1	0	0.66	0	0	0	1	0	0.66	1	0	0.66
Horseshoe	4	0	0.40	0	0	2.99	4	0	0.40	4	0	3.39
Laurel	0	0	0	0	1	3.09	0	0	0	0	1	3.09
McGee	4	4	1.20	0	0	0.00	4	4	1.20	4	4	1.20
Milestone	1	1	0.49	0	0	0	1	1	0.49	1	1	0.49
Rambaud	0	1	0.25	0	0	0	0	1	0.25	0	1	0.25
Sixty Lake	0	0	0	1	14	1.00	0	0	0	1	14	1.00
Slide	1	1	1.60	0	0	0	1	1	1.60	1	1	1.60
Swamp	0	1	0.28	0	0	0	0	1	0.28	0	1	0.28
Tablelands	0	1	1.65	0	0	0	0	1	1.65	0	1	1.65
Upper Bubbs	2	2	4.32	0	0	0.93	2	2	4.32	2	2	5.25
Upper Evolution	4	1	1.20	0	0	0.48	4	1	1.20	4	1	1.68
Upper Kern	0	2	0.38	2	8	1.47	0	2	0.38	2	10	1.85
Vidette	2	3	0.39	0	0	0.00	2	3	0.39	2	3	0.39
Total - 21 Basins	**27**	**24**	**15.58**	**4**	**25**	**15.69**	**27**	**24**	**15.58**	**31**	**49**	**31.27**

Site Assessments

A basin site assessment (assessment) was conducted for each proposed fish eradication basin to confirm the treatment approach and to identify suitable site-specific camp locations within that basin (appendix I). The assessment evaluates the feasibility of eradicating nonnative fish from proposed waterbodies in an area to return habitat to its naturally fishless state. The assessment includes determining fish distribution; quantifying and marking strategic fish barriers; surveying for MYLF distribution; providing input for restoration methods particular to each site; determining accessibility and safety; finding a low impact base camp; and establishing a safe helicopter landing zone if warranted. The assessment details basin characteristics such as elevations; number of lakes, ponds and streams along with their attributes (deep, shallow, fishless or fish presence and distribution); habitats present and connectivity; number of lakes to be treated; assignment of numeric identification (most are nameless) to lakes; most likely treatment methods and any phasing needed; and description of barriers present or barriers needed to ensure continuation of a fishless state after eradication. All site assessments were conducted by NPS staff and researchers with multiple years of experience surveying aquatic habitats in the high Sierra Nevada.

The site assessment protocol includes a defined procedure for evaluating the ability of a natural cascade to function as a fish barrier. Each cascade barrier is different depending on the unique conditions at each site. SEKI used experienced personnel and insights gained from more than 10 years of fish removal experience to judge whether a fish barrier is present at each fish eradication site. If a suitable barrier is not present, rock blasting may be used to create an impassible vertical barrier, but only if alternative C is selected and only in up to five locations. Before any fish removal proposed in the Restoration Plan/FEIS would commence, definitive confirmation of waterfall/cascade barriers would be conducted.

Additionally, one site (Upper Kern) has an upper fish barrier that would allow a small amount of physical eradication, and a lower cascade that may allow for a much larger and more effective restoration area to be produced via piscicide eradication. The upper and lower areas are both included in this plan (see appendix B). However, since there is some uncertainty as to whether the lower cascade is a fish barrier, it would be re-evaluated by additional experienced personnel before piscicide treatment may be conducted in this area. If the lower cascade is determined to not be a fish barrier, the treatment would occur further downstream to a definitive barrier, or the eradication area would be reduced physical treatment only upstream of the definitive upper barrier.

Further detail in the selection and determination of barriers can be found in the SEKI Site Assessment Protocol and Example (appendix I).

Crew Camps

Crew camps would be required for each selected project area. 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 are 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).

Crew camps would be used yearly until the project work is accomplished. There would be one to four crews working at different restoration areas from June or July through September. Crew size is typically two to three crewmembers at physical worksites, and estimated to be eight to 15 crewmembers at most piscicide worksites; more crewmembers (16 to 25) may be needed at one or one or more of the larger piscicide worksites (in Sixty Lake, Upper Kern, and Laurel). Crews would camp up to 10 days per site visit and each site would be visited up to 7 times per season. Restoration can take 1 to 10 years depending on the treatment method (physical versus piscicide) and complexity of the site. Physical restoration generally takes six years per lake and up to 10 years per stream and marsh area; restoration using piscicides would be expected to take 2 weeks per summer, over a period of one to two years total for most sites, or one to three years total for one or more of the larger sites (e.g., Sixty Lake).

Crews would comply with the parks' requirements for bear-proof storage for food and garbage. Crews would be provided with approved food-storage canisters, or 4 ft × 2 ft × 2 ft (1.2 m × 0.6 m × 0.6 m) metal bear boxes for food and gear storage. These containers and/or bear boxes would be packed into the restoration sites at the start of the season. This would enable crews to pack in the majority of their food at the start of the season to locations that are either a substantial distance from the trailhead or require a substantial amount of off-trail travel. Some equipment would be left onsite over the winter and stored in storage boxes. This would reduce the need for crews to repeatedly carry heavy packs across potentially challenging terrain or long distances reducing the likelihood of injuries. This would also provide a safe place to store gear (e.g. waders and gill nets) that smell strongly of fish and are at risk of damage by bears and other wildlife or weather events.

Prior to establishing a temporary crew camp, the following criteria would be considered:

- physical accessibility of restoration project basins – Considerations include existing trail access, amount of cross-country travel required, and potential for packstock access. All crews would hike to project areas, backpacking in lightweight equipment and personal supplies. Crews would not be transported by other means except in case of a medical emergency.
- base camp location priorities – Camp locations should be selected based on the following conditions: available granite slabs or decomposed granite substrate generally absent of vegetation; out of MYLF and Yosemite toad migration routes; consideration of visitor wilderness experience by blending into the surrounding environment using trees for camouflage and staying away from developed trails; sites more than 100 ft (30 m) from water; proximity to water for drinking and cooking; proximity to landing zone for optimum gear transport.
- travel from base camp to all restoration sites – The preferred maximum hike to restoration sites from base camp would be approximately 30 minutes.
- exposure to risks – Camp site selection would minimize the potential for exposure to risks, such as extreme weather, tree hazards, lightning, altitude sickness and exposure to cliffs and extreme terrain.

Use of Helicopters and Stock
All fieldwork for alternatives B, C, and D would require transport of tools and equipment in and out of the proposed project sites. The type of transport is guided by the Wilderness Act, NPS policies, and the SEKI Wilderness Stewardship Plan (NPS 2015B). This document defines the minimum tool as “the management method (tool) that causes the least amount of impact to the physical resources and experiential qualities (character) of wilderness.”

Stock would be used for mobilizations and demobilizations of physical treatment sites. Stock would be used for two round trips per site, one to two sites per year. In general, site mobilizations require five animals and demobilizations require three to four animals. Consequently, maximum yearly stock use is estimated to be eight to nine 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. From 2003 to 2012, the yearly average number of stock nights from administrative, commercial, and private use in SEKI is 6,775 nights (NPS 2015B). If this number remains constant, and project stock use utilized the maximum expected stock nights per year (18 nights) for the 25 to 35 year life of the plan, project stock use is only projected to increase park stock use by 0.1% each year. Program managers would require supplemental feed in sensitive meadows.

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 in 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 (e.g. by the creation of new trails, by off-trail travel in sensitive environments, etc.).
- 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.

Whenever any one of those conditions applies, a Light (Type 3) helicopter would be defined as the minimum tool for transportation of cargo. 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 sites. Additional flights could be needed for restoration activities (to transport MYLFs between sites).

Monitoring
Monitoring of the short- and long-term outcomes of restoration work would document MYLF and ecosystem responses to restoration efforts. The analysis of the biological data would provide further insight regarding effects to ecosystems from nonnative fish and restoration methods, managing genetic diversity within species populations, interactions between stressors, and discovery of issues yet unknown. The knowledge gained through monitoring would be incorporated into adaptive management. The information gathered would also add to public and staff understanding of the continuing threats to high elevation ecosystems from nonnative species, air pollution, climate change, new pathogens, and other environmental stressors.

<u>Visual Encounter Survey</u>
Pre- and post-restoration monitoring would focus on frog populations, other native species populations, and changes to the ecosystems that may have been affected by restoration activities, particularly where piscicide treatment would be used. The primary tool for monitoring frog populations is a non-invasive method known as a visual encounter survey (VES), in which a surveyor counts all individuals encountered while slowly walking along a lakeshore or stream section, and records each individual by their life stage (adult, juvenile, larvae/tadpole, or egg mass). VES would be conducted at all MYLF sites, as well as treatment (fish eradication) and control (fish-containing and historically fishless) lakes in each fish eradication basin. During each VES, surveyors would document environmental variables (e.g., temperature, weather), number/life stage of amphibians and reptiles, presence/absence of fish and their redds (egg nests), and any interesting observations. Surveyors would limit conducting VES during inclement weather, such as high winds or precipitation, because frogs are less detectable during these conditions. Depending on the specific location within the parks, the list of potential species that may be detected includes MYLFs, Pacific treefrog (*Pseudacris regilla*), Yosemite toad, western toad, mountain garter snake, and Sierra garter snake (*Thamnophis couchii*). Skin swabs would also be collected from MYLFs during some visual surveys to monitor for presence of amphibian chytrid fungus. Disease monitoring would focus on areas where amphibian chytrid fungus is not yet known to occur, in order to detect disease outbreaks and conduct antifungal treatments to increase frog survival; swabs may also be collected from MYLFs in areas where infection is known to be present.

<u>Capture-Mark-Recapture</u>
Though useful for general monitoring purposes, VESs are known to produce underestimates of true population size (Mazerolle et al. 2007). Capture-mark-recapture (CMR) surveys account for detection probability and result in larger and more accurate estimates of population size (Williams et al. 2002). These data can be used to more reliably determine whether or not a percentage of the population can be collected for recovery efforts. To conduct CMR surveys, surveyors capture adult and juvenile MYLFs that have a snout-to-vent length (SVL) greater than or equal to 1.5 inches (38 mm) from lakes using dip nets. Each MYLF would be sexed, weighed, and swabbed to determine amphibian chytrid fungus infection levels. To mark each frog, an 8 mm passive integrated transponder (PIT) tag would be inserted under the surface of the dorsal skin. To insert PIT tags, a tiny incision is made just behind the head on the

dorsal surface of the MYLF and the PIT tag is inserted and moved to behind the pelvic girdle (Briggs et al. 2010). This assures that the PIT tag remains on the dorsal surface, but cannot move above the pelvic girdle. CMR surveys depend on each animal having a unique identifying feature, and because it is difficult to distinguish individual MYLFs based on color patterns or other morphological features, PIT tags are a necessary tool. Each PIT tag contains a unique alphanumeric code and can be read with hand-held readers. Every time a MYLF is captured, the surveyor can correctly identify each individual.

<u>Post-Fish Eradication</u>
In all action alternatives, fish eradication sites would be monitored to determine that complete fish eradication has been achieved. For physical fish removal methods, initial confirmation of fish eradication would be determined using the methods employed since 2001 in SEKI. This method involves conducting gill-netting and electrofishing until there is a winter, the following summer, and a second winter with no fish captures. If no fish are captured during this period, active fish removal efforts cease. For piscicide applications, the entire treatment area would be surveyed for any live fish using visual searches, angling, gill-netting, and/or electrofishing in the days/months immediately following treatment and during the subsequent summer.

For all treatment methods, post fish eradication monitoring would occur from two to five years to confirm the continued absence of fish. A small number of gill nets, deployed anywhere between one day and one month, may be used along with visual surveys to confirm fish absence. If fish are discovered in a restored site, eradication crews would return for follow-up fish removal efforts. Feedback from this monitoring would inform park managers and researchers about the results of fish eradication efforts, and be incorporated into future management activities.

Environmental DNA (eDNA), is an emerging technique that may prove useful as an additional method for confirming fish eradication in which water samples are collected from aquatic environments to detect species (Pilliod et al. 2013, Keskin 2014, Turner et al. 2015). This method involves amplifying small fragments of DNA from water samples using species-specific DNA primers, which allow for the detection of species from quantities of DNA present in the environment (Wilcox et al. 2013). Research into this method shows potential as a non-invasive monitoring tool (Takahara et al. 2012, Wilcox et al. 2015). Research is currently ongoing to determine the feasibility of eDNA methods for detecting low density fish populations, or confirming eradication, in high elevation aquatic ecosystems in SEKI (Kamoroff C, pers. comm., 2016). If eDNA methods prove useful for confirming nonnative trout absence in restored waterbodies, this method may be incorporated into monitoring of fish eradication sites.

Restoration of Mountain Yellow-Legged Frogs
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 many locations where populations have recently been extirpated. Nonnative fish removal would be a primary step in restoring MYLFs, other native species and natural function to high elevation aquatic ecosystems.

All lake basins identified for fish eradication or known to have historic or current occupancy by MYLFs (Table 7 and Table 9, Figure 6) would be considered potential MYLF restoration sites. MYLF restoration actions would be aligned with the nearly-complete Mountain Yellow-legged Frog Conservation Strategy (FWS *in preparation*). Recommended actions include nonnative fish eradication, translocation/reintroduction, antifungal and beneficial bacteria treatment, immunization, headstarting/captive rearing, and emergency salvage. MYLF restoration would be based on the best science available, and protocols would be researched, developed, implemented, monitored, and refined in collaboration with other federal and state agencies (e.g., FWS, USFS, USGS, and CDFW) and academic researchers.

The restoration activities would take place in up to 55 basins depending on the alternative selected. The proposed restoration areas were selected to capture (1) geographic and elevational representation of the historic distribution of MYLFs, (2) the known genetic diversity of MYLFs, (3) areas of potential high-quality habitat, and (4) known persistent MYLF populations that may be important to future restoration. These 55 basins include up to 21 basins in which nonnative fish would be eradicated from at least one waterbody, plus 34 additional basins where no fish would be eradicated (includes four basins with fish eradications completed under the existing approved plan). The fishless basins were included as potential restoration basins because they had a recent history of MYLF populations or have existing MYLF populations, including some that have demonstrated survival persistence in spite of being infected by amphibian chytrid fungus. Successful reintroduction would restore MYLFs to these basins, assuming the original cause of decline or extirpation can be managed.

All of the 55 restoration basins contain various amounts of lakes, ponds, streams and associated wetlands that are fishless. Restoring connectivity between multiple waterbodies would improve movement between frog breeding, feeding, and over-wintering habitat where occupied MYLF habitat is nearby. In locations with high quality but unoccupied MYLF habitat, or where restoration sites are isolated from existing frog populations, physical reintroductions (transporting frogs from one site to another) would occur.

<u>Antifungal and Beneficial Bacteria Treatment</u>
Itraconazole (Sporonox®) is an antifungal compound that has been used to clear amphibian chytrid fungus from amphibians, typically in a laboratory setting. Whether antifungal treatments are conducted in the field or in a laboratory setting (i.e., at a zoo), the solution ratio is 0.15 ml (about three drops) of itraconazole to 1 L of water. After that is mixed, the frogs (usually adults and/or juveniles) are placed in the solution for 10 minutes and positioned such that they are mostly submerged in the solution but can still hold their heads above to breathe. The frogs are then moved to a holding pen so that they can be treated again, once per day, for 6 to 10 days. If MYLFs were treated in the field, the treatments would likely occur at the source site. Under current methods, frogs would be held in mesh pens (6.5 ft × 6.5 ft × 1.6 ft/ 2 m × 2 m × 0.5 m) anchored in the lake that allow the frogs to both swim in the water and bask on the shoreline. Animals would be treated once a day by moving 20 to 50 frogs at a time into plastic tubs containing the itraconazole solution. They would be bathed in the treatment solution for 10 minutes per day and then returned to the pen. After full treatment is completed, animals would be transported to the receiving lake. If deemed necessary, the animals may also be treated with *J. lividum* that was collected from the source population and cultured in the laboratory. At the receiving lake, frogs would be held for 2 days in mesh pens anchored in the lake. Up to 50 frogs at a time would each be placed in small 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 2 days and then returned to the pens between the two treatment sessions. The frogs would be released into the receiving lake after the second day of treatment. Although bioaugmentation is not frequently utilized in the parks currently, this form of treatment is a potentially useful tool that may be implemented more in the future (Harris et al. 2009). These methods and their efficacy are still in development and could change over the course of this plan.

<u>Translocation/Reintroduction</u>
To mitigate the extensive losses of MYLF populations, post-metamorphic individuals >1.5 inches (~38 mm) SVL would be moved from extant populations to areas where populations recently died out or have severely declined. Post-metamorphic frogs would be translocated from one or up to several different populations within the same clade. Translocations involving more than one "persisting" population (i.e., a population in which amphibian chytrid fungus is already present and a small population is persisting with the disease) could help increase genetic diversity and improve the potential for disease resistance. Movement would involve (1) capturing a small percentage (typically <10%; see discussion related to this percentage in Captive Rearing below) of the individuals in a source population using dipnets; (2) measuring the body condition of each animal (length, weight, sex, amphibian chytrid level); (3) inserting

a PIT tag under the skin of each frog (Matthews and Preisler 2010) to monitor the status of each animal following reintroductions; (4) placing them in wetted containers with air holes; (5) potentially treating frogs prior to translocation with antifungal drug (e.g., itraconazole); (6) potentially bioaugmentation with naturally occurring bacteria, *Janthinobacterium lividum*; and (7) either hiking them to nearby recipient habitat or transporting them by helicopter to distant recipient habitat. 'Nearby' habitat generally can be hiked to within 6 hours and poses a minor risk to frog survival during transport. 'Distant' habitat cannot be hiked to within 6 hours and would pose a moderate to high risk to frog survival during transport. The 6-hour timeframe is based on the experience of professional herpetologists, who concluded that about one full morning of hiking is an approximate maximum timeframe appropriate for transferring MYLFs in transport containers in a backpack to minimize stress from heat and jostling. Therefore, moving frogs to distant sites would involve the use of helicopters. Whether frogs are given antifungal and/or bacterial treatments would depend on whether (1) preliminary studies (to be completed by 2017) confirm these agents are beneficial, and (2) a targeted population is severely affected by amphibian chytrid fungus and thus needs treatment to increase survival. At the recipient site, all individuals would be released into fishless habitat and monitored for the next several years.

<u>Captive Rearing</u>
MYLF populations infected with amphibian chytrid fungus in SEKI typically contain a small number of adults that are persisting and breeding, and a greater abundance of tadpoles and recently metamorphosed juveniles that experience very low survival, with few animals reaching adulthood. Survivial to adulthood is low because amphibian chytrid fungus infects epidermal cells containing prekeratin and keratin, which develop throughout the skin as the MYLFs metamorphose (Voyles et al. 2011). In tadpoles, the mouthparts are the primary location affected, so most direct mortality is not observed until after metamorphosis (Vredenburg et al. 2010A). While these populations may adapt to amphibian chytrid fungus in the field, captive rearing can help increase the chance for them to persist and recover by allowing more animals to survive and by allowing animals to be immunized. Captive rearing would generally involve collection of adults from uninfected sites, and eggs, tadpoles, and/or juveniles from infected sites, for transport to a suitable captive rearing facility. In uninfected sites, it is generally permissible to collect up to 10% of adults for captive rearing, due to comparatively large population sizes at uninfected sites. In infected sites, a larger percentage of eggs, tadpoles, and/or juvenile MYLFs may be permissible for collection because few, if any, of these individuals would reach adulthood without some kind of intervention (e.g., antifungal treatment and immunization). For each source population, the number of individuals removed at one time would be dependent on the estimated population size. SEKI would use available population data and site-specific experience to propose high-priority actions to the MYLF recovery team. The information would be reviewed by the team, decided by consensus using professional judgment, and would ultimately have to be endorsed by FWS (as the regulatory agency of the ESA) before the action could be implemented. Once collected, MYLFs are kept cool (i.e., to ensure they remain well below their thermal maximum temperature), and transported immediately, by foot, helicopter and/or vehicle, to minimize stress. At the captive rearing facility, MYLFs are raised to adulthood, infected with amphibian chytrid fungus, and then treated with antifungal drugs to eliminate their infection. A portion or all these frogs then may be reinfected and retreated with antifungal drugs to evaluate the level of disease resistance achieved by each frog. The treated frogs can then be reintroduced to a site in which amphibian chytrid fungus is already present, including their source location or a different site depending on conservation needs.

<u>Salvaging Drought-threatened Populations</u>
Small ponds are not optimal habitat for MYLFs. However, the importance of small ponds increases with the widespread presence of nonnative fish in larger, more suitable lake habitat. Despite often lacking nonnative fish, small ponds tend to be shallower and more susceptible to complete drying during summer. MYLFs require two to four years of permanent water for tadpoles to complete metamorphosis and reach adulthood. Thus, the potential complete drying of these smaller ponds can cause high local mortality

across multiple frog cohorts (Lacan et al. 2008). When combined with the severely reduced MYLF breeding and recruitment success in larger lakes that contain nonnative fish, the drying of small ponds has the potential to result in extirpation of MYLF populations simply as the result of stochastic environmental events. Salvaging MYLF populations can serve as a tool against potential extirpation when MYLFs are restricted to small ponds that are at risk of complete desiccation. In such cases, frogs at any life stage may be collected and transported to a captive location using the same protocol described above. In captivity, MYLFs can be kept until habitat conditions become suitable again and then released, or can be used to establish a captive breeding program. By establishing a captive breeding program, more animals may be able to successfully develop, and any life stage can be released into wild sites. Additionally, if the drying habitat is isolated from other waterbodies, MYLFs could be transported to nearby perennial fishless habitat. However, this type of movement would only be undertaken if the more drought resilient habitat is located farther away than many MYLFs could likely migrate before the habitat in which they are located dries (i.e., more than about 100 meters; Pope and Matthews 2001).

<u>Mountain Garter Snake Relocation</u>
Mountain garter snake predation has compromised the success of at least two MYLF reintroductions in SEKI and YOSE (Knapp R., unpublished data). Mountain garter snake presence appears to increase substantially at some locations into which MYLFs have been reintroduced. For example, daily individual snake observations ranged from 0 – 3 at sites prior to MYLF reintroduction, but increased to 20 individual snakes observed on one particular day following MYLF reintroduction (Knapp R., pers. comm., 2013). Furthermore, snakes have been observed actively preying on reintroduced frogs: one individual snake contained two reintroduced MYLFs in its stomach (as determined by PIT tag readings) (Knapp R., pers. comm., 2015; Halstead et al. 2016).

Given currently limited capacity at captive-rearing facilities and the endangered status of MYLFs at donor sites, a relatively small number of MYLFs are anticipated to be available for translocations and reintroductions. Therefore, all mountain garter snakes detected would be relocated up to several kilometers away from recipient sites for one to two years following MYLF reintroduction. Mountain garter snakes detected during monitoring would be captured, marked, and moved by foot to a site in the same basin that does not have MYLFs. It is expected that a maximum of 20 snakes would be relocated from all reintroduction sites in any given year. The goal would be allowing incipient MYLF populations the chance to successfully breed and increase in abundance to the point where the population is self-sustaining. Limiting direct predation during this critical acclimation period may allow small MYLF populations the ability to withstand natural predation once snake relocations cease.

Studies related to garter snake movement come from similar species, but may not be directly relevant to mountain garter snakes in SEKI. The potential benefit of garter snake relocations to MYLFs also needs determination. Therefore, beginning in 2016, research collaborators are initiating a study on garter snake relocations in SEKI and YOSE to address these very questions (Halstead et al. 2016). The study objectives include (1) evaluating mountain garter snakes probability of occurrence at aquatic sites, and relate that probability to biotic and abiotic variables that allow mountain garter snake occupancy estimation at proposed MYLF reintroduction sites, (2) estimate abundance and diet of mountain garter snakes at MYLF sites before and after reintroduction, and (3) evaluate the effectiveness of translocating mountain garter snakes as a tool to mitigate the threat of predation on reintroduced MYLFs (Halstead et al. 2016).

Adaptive Management
Adaptive management is a system of management practices based on clearly identified desired conditions and monitoring to determine whether management actions are achieving objectives and, if not, facilitating management changes that would best ensure that the desired conditions are met or re-evaluated (Walters and Holling 1990, Williams et al 2007). Adaptive management is a technique employed for charting a

decision-making course along an uncertain path whose goal is to obtain an expected and desirable condition. An effective monitoring program is required to provide the navigational framework needed for successfully meeting the challenges of adaptive management.

Adaptive management recognizes that knowledge about natural resource systems is sometimes uncertain (43 CFR 46.30; Moir and Block 2001, Ruhl 2005). Adaptive management considers management actions and policy in a context analogous to experimental treatments. Thus, it embraces uncertainty by defining a set of quantitative responses that are consistent with management experience for each desired condition (hypothesized outcome). This is often accomplished through the use of various conceptual or quantitative models. The evidence for achieving the conditions/outcomes is considered in a well-designed monitoring framework, just as one would expect from any research design. Sampling designs that monitor pre-determined performance metrics from the outset can help reduce uncertainty.

Adaptive management integrates science and management (Lee 1993). From a science perspective, management objectives become the primary response of interest and the source of questions being posed. From a management perspective, the management objectives remain the primary concern, but learning becomes an additional, explicit objective. Thus, management takes on a part of science (i.e., learning), and science takes on a part of management (i.e., the objectives). More detailed information about the use and implementation of adaptive management is given in *Adaptive Management: The U.S. Department of the Interior Technical Guide* (Williams et al. 2009).

Adaptive management is a major and integral feature of alternatives B, C, and D in this EIS. The adaptive management approach would include statistically valid long-term monitoring to evaluate effectiveness of conservation actions. Managers need to understand how MYLF populations that are persisting in spite of amphibian chytrid infection can continue to be protected and how they might contribute to restoring extirpated MYLF populations. Options for treating amphibian chytrid fungus in the field need to be explored. Scientific research allows for expansion of management tools available today and provides information that can be incorporated into future management activities. Stakeholders, such as the FWS, USFS, USGS, and CDFW would continue to be fully engaged.

Continuing Research

NPS policy supports research to enable park managers to develop effective management tools based on understanding threats to park ecosystems, and to identify which stressors are most serious, which are manageable, and ways they could be managed. At SEKI, ongoing research by partners and outside entities provide SEKI managers with current information to help them develop management strategies to ensure the preservation and conservation of high elevation aquatic ecosystems for future generations.

Continued research at SEKI would support ongoing scientific effort to:

- develop additional management options to conserve MYLFs
- maintain genetic diversity in MYLF populations
- investigate possible effects of atmospheric deposition of agricultural and industrial contaminants
- understand the effects related to climate change (habitat loss, reduced resistance to diseases)
- further investigate broad-scale ecosystem effects of nonnative fish
- further investigate localized ecosystem effects of fish eradication methods
- better understand interactions between environmental stressors
- determine the best source populations for MYLF reintroductions and translocations (wild, captive, or both)

- refine methods to transport specimens for reintroductions
- further investigate methods to consistently achieve successful reintroductions
- investigate if there is an optimum timing of reintroductions
- investigate alternative, new, or refined methods for mitigating the effects of amphibian chytrid fungus to increase the success rate of MYLF reintroductions
- research and develop specialized treatment of amphibian diseases (such as amphibian chytrid fungus) using local populations to target site specific conditions
- allow discovery of new information

Given the implementation period of 25 to 35 years for this Restoration Plan/FEIS, incorporation of scientific research and adaptive management to maximize project effectiveness would be an essential element to effectively restore and conserve the natural abundances, distributions, and functions of native species, populations, and communities within high elevation aquatic ecosystems.

Fish Disposal
In all of the action alternatives, eradicated fish would accumulate and require disposal. At sites where fish would be removed using physical methods, on a daily basis, crews would puncture the swim bladders of all fish captured (to prevent them from floating) and sink them in deep water to the bottom of each restoration lake. Crews would dispose of stream fish taken by electrofishing by puncturing their swim bladders and sinking them in deep water to the bottom of the nearest restoration lake. Physical fish removal slowly spreads out nutrient loading from fish decomposition over an extended period of time.

At sites where high density fish populations would be eradicated using piscicides, dead fish may float to the surface in potentially large numbers. Large fish kills resulting from piscicides would remain in larger waterbodies, or carcasses would be moved from small, shallow waterbodies to nearby larger waterbodies. In cases where myriad fish are killed in a short time period and concentrated in one area, fish carcasses would be distributed among nearby larger and deeper waterbodies within the same basin.

The swim bladders of any floating fish would be popped so the carcasses sink to the substrate. Most lake systems in the high Sierra are oligotrophic (nutrient lacking). Therefore, allowing nutrients present in fish populations to be released directly to the aquatic ecosystem through decomposition is an important step for retaining limited nutrients and would be a long-term benefit to the restoration areas.

ALTERNATIVE B: PRESCRIPTION TREATMENT (PHYSICAL AND PISCICIDE) PRECEDING RESTORATION (NPS PREFERRED ALTERNATIVE)

Under this alternative, a prescription (detailed plan of action) for restoration would be developed for each proposed restoration area based on the criteria for basin selection, pre-treatment surveys, habitat size, basin topography, wilderness values, visitor use and field crew safety. Prescriptions would consider the actual distribution of fish, results of invertebrate surveys and unique habitats such as springs and thermal features. Both physical and piscicide treatment methods would be considered for nonnative fish eradication. Waterbodies determined infeasible for physical treatment would be restored using piscicides.

Based on current knowledge of the proposed fish eradication sites, physical treatment would be used for 52 waterbodies (27 lakes, 24 ponds, 1 marsh; total of 492 ac/199 ha) and approximately 15 mi (25 km) of streams in 17 basins; piscicide treatment would be used for 33 waterbodies (4 lakes, 25 ponds, and 4 marshes; total of 142 ac/57 ha) and approximately 16 mi (25 km) of stream in 9 basins (Table 9, Table 10, and Table 11). In addition, any fish-containing habitat adjacent to treated lakes, ponds and streams identified during fieldwork would also require treatment (physical or piscicide depending on conditions) 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 waterbodies and stream miles identified for treatment represents the maximum number of waterbodies to be treated in this alternative. If selected, piscicide treatments would occur starting in 2017, at the earliest.

Location of Proposed Treatments
The following locations would be included in this alternative. Aquatic ecosystem restoration would take place in 55 basins (Table 7, Figure 6), as indicated in detail by purple (physical treatment waterbodies) and yellow (piscicide treatment waterbodies) in Figure 7 below. Orange denotes fishless waterbodies in close proximity to locations in which nonnative fish removal (i.e., physical and/or piscicidal eradication) has been proposed (Figure 7), and fishless basins in which restoration actions that do not include fish removal may take place (Figure 6). Nonnative fish would be eradicated from selected waterbodies in 21 basins (Figure 5, Table 9, Table 10 and Table 11), including 80 lakes and ponds (602 ac/244 ha), 5 fish-containing marshes (32 ac/13 ha), approximately 31 mi (50 km) of stream, plus additional connected fish-containing habitat if necessary. These 85 waterbodies represent 15% of the parks' 550 waterbodies known to contain nonnative fish that are candidates for eradication.

Development of the Site-Specific Treatment Plans
For physical fish eradication sites, a completed site assessments would set forth the site-specific treatment plans for each site (for an example, see appendix I). For piscicide eradication sites, detailed basin prescriptions would be developed during years immediately prior to treatment so that information would be as current as possible when the treatment begins. The precise areas to be treated with piscicides 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, location of natural fish barriers, 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). In addition, baseline invertebrate surveys would be conducted prior to the first two to three treatments to measure the actual results of the treatment actions (see Appendix N).

Under alternative B, physical treatment is the preferred method. Piscicide treatment is prescribed where: (1) a lake is too large or lacks accessible 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. In addition, if a waterfall or cascade expected to be a fish barrier at the bottom of a physical treatment area proves inadequate in preventing fish passage, piscicides would be used in the aquatic habitat below the inadequate cascade in order to eradicate fish down to a definitive fish barrier. The waterbodies 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. Waterbodies that would provide more value in the face of climate change (i.e. large, deep, and/or cold waterbodies that can buffer drying and warming) were included for fish eradication in this plan.

Fishless habitat in the 21 fish eradication basins, plus 34 additional basins (Table 7, Figure 5 and Figure 6) where no fish eradication would occur, would receive conservation actions to benefit MYLFs and other native species.

Table 10 lists all basins proposed for nonnative fish eradication using physical and piscicide treatment under alternative B, including the number of lakes, ponds and stream miles per treatment method per basin. Not included in this table are five known fish-containing marshes (totaling 32.42 ac/13 ha) that are also proposed for nonnative fish eradication: one marsh (1.53 ac/0.6 ha) located in the Tablelands (physical treatment); one marsh (8.63 ac/3.5 ha) located in Crytes (piscicide treatment); and three marshes (totaling 22.26 ac/9 ha) located in Laurel (piscicide treatment).

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Table 10. Basins and waterbodies proposed for nonnative fish eradication under alternative B

Basin	# Lakes	Area (ac)	# Ponds	Area (ac)	Stream (mi)
Physical Treatment					
Barrett	3	42.07	1	0.28	0.87
Blossom	2	9.45	2	2.29	0.64
Brewer	0	0	1	1.60	0.52
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	28.96	0	0	0.40
McGee	4	75.31	4	1.19	1.20
Milestone	1	12.80	1	2.07	0.49
Rambaud	0	0	1	0.44	0.25
Slide	1	5.12	1	0.17	1.60
Swamp	0	0	1	1.85	0.28
Tablelands	0	0	1	1.48	1.65
Upper Bubbs	2	21.62	2	1.67	4.32
Upper Evolution	4	228.19	1	0.48	1.20
Upper Kern	0	0	2	2.12	0.38
Vidette	2	16.57	3	0.23	0.39
Subtotal Physical	**27**	**473.91**	**24**	**17.34**	**15.58**
Piscicide Treatment					
Amphitheater	1	58.87	2	1.34	2.16
Crescent	0	0	0	0	1.58
Crytes	0	0	0	0	1.99
Horseshoe	0	0	0	0	2.99
Laurel	0	0	1	0.22	3.09
Sixty Lake	1	13.36	14	14.87	1.00
Upper Bubbs	0	0	0	0	0.93
Upper Evolution	0	0	0	0	0.48
Upper Kern	2	18.32	8	4.17	1.47
Subtotal Piscicide	**4**	**90.56**	**25**	**20.61**	**15.69**
Grand Total	**31**	**564.46**	**49**	**37.95**	**31.27**

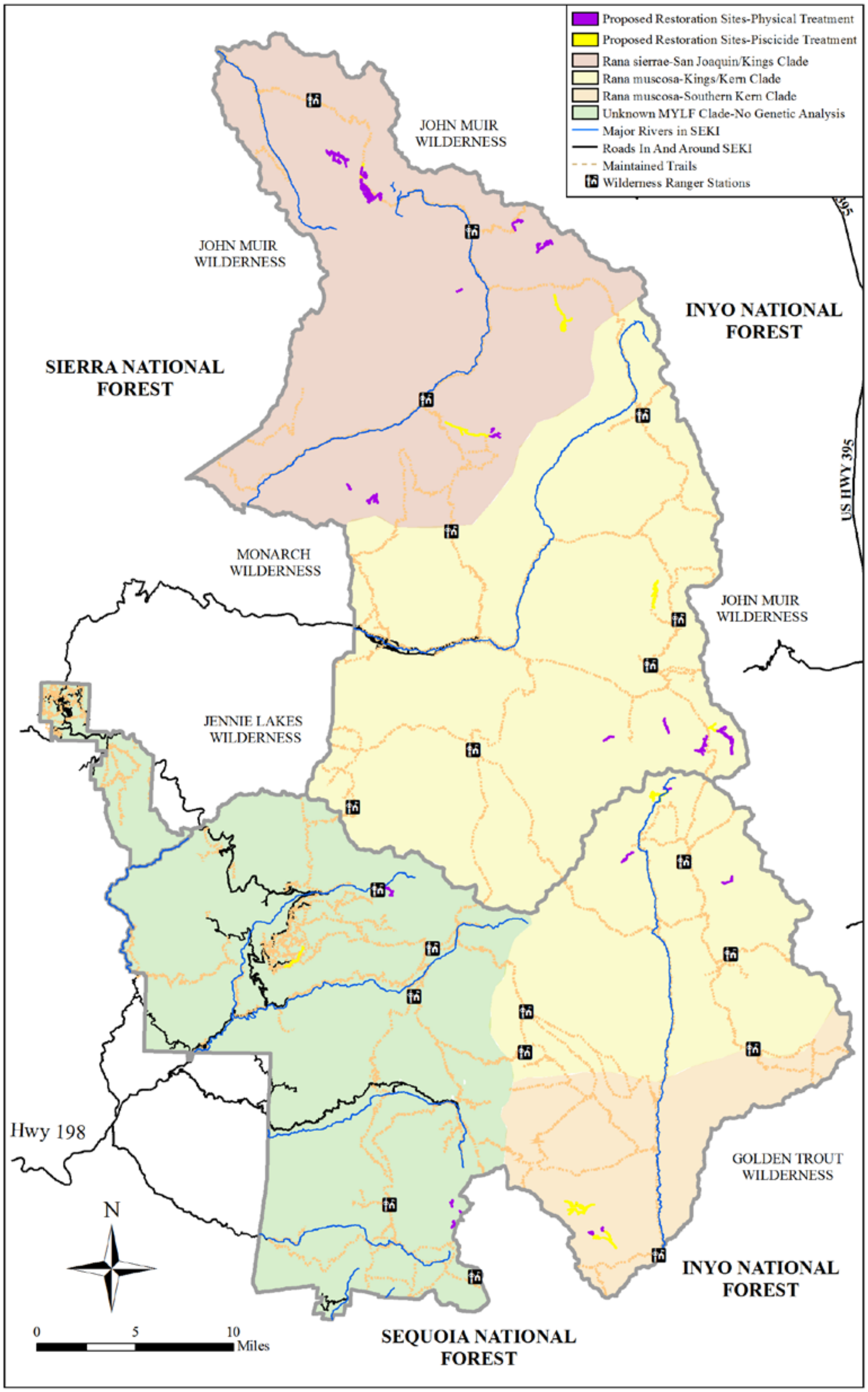

Figure 7. Map of basins proposed for nonnative fish eradication under alternative B

This map includes physical treatment waterbodies and streams in purple, and piscicide treatment waterbodies and streams in yellow.

Table 11. Surface area and wetland class by treatment type of 85 waterbodies proposed for nonnative fish eradication under alternative B

Treatment	Wetland Class	Area (ac)	Area (ha)	Basin
PHYSICAL	**Pond**	0.04	0.02	Vidette
		0.04	0.02	Vidette
		0.10	0.04	McGee
		0.12	0.05	McGee
		0.13	0.05	Dusy
		0.15	0.06	Vidette
		0.16	0.06	Blossom
		0.17	0.07	Slide
		0.28	0.11	McGee
		0.28	0.11	Barrett
		0.44	0.18	Rambaud
		0.47	0.19	Dusy
		0.48	0.20	Upper Evolution
		0.58	0.23	Upper Bubbs
		0.70	0.28	McGee
		0.87	0.35	Crytes
		0.87	0.35	Upper Kern
		1.09	0.44	Upper Bubbs
		1.25	0.51	Upper Kern
		1.48	0.60	Tablelands
		1.60	0.65	Brewer
		1.85	0.75	Swamp
		2.07	0.84	Milestone
		2.14	0.86	Blossom
	Lake	2.63	1.06	East Wright
		2.75	1.11	Horseshoe
		3.16	1.28	Barrett
		3.23	1.31	Vidette
		3.38	1.37	Upper Bubbs
		3.52	1.42	Horseshoe
		4.11	1.66	Blossom
		4.44	1.80	Upper Evolution
		4.65	1.88	Crytes
		5.12	2.07	Slide
		5.34	2.16	Blossom
		8.26	3.34	McGee
		9.78	3.96	Horseshoe
		9.87	4.00	Barrett
		10.58	4.28	Dusy
		12.80	5.18	Milestone
		12.91	5.22	Horseshoe
		13.34	5.40	Vidette
		15.00	6.07	McGee
		15.97	6.46	Crytes
		18.25	7.38	Upper Bubbs
		21.36	8.64	Upper Evolution
		25.02	10.12	McGee
		27.04	10.94	McGee
		28.53	11.55	Upper Evolution
		29.03	11.75	Barrett
		173.86	*70.36*	*Upper Evolution**
	Marsh	0.87	0.35	Tablelands
TOTAL		**492.12**	**199.15**	

**One very large lake (174 ac/70 ha) in Upper Evolution is essentially fishless. However, a few individual fish have been seen (NPS 2011C), so it is included as a fish-containing lake. It appears fish only occasionally enter this lake from upstream habitats and are not reproducing in this lake.*

Table 11 continued.

Treatment	Wetland Class	Area (ac)	Area (ha)	Basin
PISCICIDE	**Pond**	0.140	0.057	Amphitheater
		0.175	0.071	Sixty Lake
		0.220	0.089	Laurel
		0.269	0.109	Upper Kern
		0.276	0.112	Upper Kern
		0.304	0.123	Upper Kern
		0.307	0.124	Upper Kern
		0.329	0.133	Sixty Lake
		0.350	0.142	Sixty Lake
		0.390	0.158	Upper Kern
		0.408	0.165	Sixty Lake
		0.439	0.177	Sixty Lake
		0.451	0.183	Upper Kern
		0.453	0.183	Sixty Lake
		0.540	0.219	Sixty Lake
		0.673	0.272	Sixty Lake
		1.085	0.439	Upper Kern
		1.091	0.442	Upper Kern
		1.132	0.458	Sixty Lake
		1.202	0.486	Amphitheater
		1.334	0.540	Sixty Lake
		2.129	0.862	Sixty Lake
		2.186	0.885	Sixty Lake
		2.261	0.915	Sixty Lake
		2.465	0.998	Sixty Lake
	Lake	3.445	1.394	Upper Kern
		13.363	5.408	Sixty Lake
		14.876	6.020	Upper Kern
		58.872	23.824	Amphitheater
	Marsh	4.497	1.820	Laurel
		7.048	2.852	Laurel
		8.632	3.493	Crytes
		10.713	4.335	Laurel
TOTAL		**142.055**	**57.488**	

Proposed Treatment Methods

Under this alternative, physical treatment tools would consist of gill-netting, electrofishing, trapping, and disruption and/or covering of redds. The estimated timeline of physical treatments is from 2016 to 2045 (Table 12). Piscicide treatment would use a rotenone-based product, currently CFT Legumine™. The estimated timeline of piscicide treatments is from 2017 to 2036 (Table 13). Specific details of each treatment method are described following Table 12 and Table 13.

Table 12. Estimated timeline of physical fish eradication treatments under alternative B.

In general, priority tier 1 would be implemented before priority tier 2, and priority tier 3 would be implemented last. The actual implementation sequence would depend on urgency related to completing physical eradication habitats, complexity of habitat, MYLF habitat restoration need, funding, logistics, and weather. The "MYLF Species" column shows the range of MYLF in which each basin is located. Fish eradication would create an interconnected network of fishless habitat that would benefit all native species, including federally endangered MYLFs. Restoration is needed in all proposed basins to provide large, deep lakes and/or a diverse array of quality habitat for sustaining more robust populations of native species. Additionally, proposed restoration would provide aquatic habitats better able to withstand drying and warming expected with climate change.

Priority Tier	Estimated Years of Treatment	Site Name	MYLF Species	Rationale
1	2016-2025	Upper Bubbs (Center)	*R. muscosa*	Fish were eradicated from two lakes in the Center Basin portion of this restoration area, but the cascade estimated to be a fish barrier below one of the lakes is allowing fish to pass and recolonize the restoration habitat. Eradicating fish in the basin until a definitive cascade barrier downstream is needed to complete the current eradication lake, establish fishless habitat connectivity between the two existing fish eradication lakes, and provide a diverse array of connected fishless habitat. Once physical methods have removed fish from the upstream, primarily lentic, habitat (~2020), piscicides would likely be needed in the basin outlet stream to completely eradicate fish, due to a long section of complex stream habitat before reaching the definitive fish barrier.
		McGee	*R. sierrae*	Current fishless habitat is limited to a set of peripheral lakes and ponds disconnected from each other by a complex of interconnected fish-containing lakes and streams in the geographic center of the basin. All fish removal can be completed using physical methods.
		Upper Evolution	*R. sierrae*	Current fishless habitat is limited to a set of peripheral ponds and one lake, disconnected from each other by a complex of interconnected fish-containing lakes and streams in the core of the basin. Fish eradication habitat includes Wanda Lake, which, although very large, contains a very low density, non-breeding fish population that can be removed using physical methods. Following physical eradication in most areas (~2025), piscicides may be needed in some locations due to long sections of complex stream habitat (shallow, cobbles, braids, marshy) before reaching the definitve fish barrier.
		Barrett	*R. sierrae*	Current fishless habitat is limited to a set of peripheral ponds and lakes disconnected from each other by a complex of interconnected fish-containing lakes and streams in the core of the basin. All fish removal can be completed using physical methods.
		Dusy	*R. sierrae*	Current fishless habitat is limited to a set of small peripheral ponds disconnected from each other by two fish-containing lakes/ponds, one of which is the largest lake in the basin. All fish removal can be completed using physical methods.
		Milestone	*R. muscosa*	Current fishless habitat is limited to a set of small ponds disconnected from each other by two fish-containing lakes that are the largest lakes in the basin. All fish removal can be completed using physical methods.
2	2026-2035	Vidette	*R. muscosa*	Current fishless habitat is limited to a set of peripheral ponds and one lake, disconnected from each other by two interconnected fish-containing lakes and streams in the core of the basin. All fish removal can be completed using physical methods.
		Brewer	*R. muscosa*	Current fishless habitat is limited to a set or peripheral lakes, ponds and streams in the lower and upper parts of the basin disconnected from each other by one fish-containing lake and stream section in the core of the basin. All fish removal can be completed using physical methods.
		Crytes	*R. muscosa*	Current fishless habitat is limited to one small isolated pond in the headwaters of the basin. The only two lakes in the basin contain fish. Fish can be removed from the lakes using physical methods. Piscicide treatment is needed to remove fish from long sections of the lake outlet streams and connecting marshy areas in order to establish fishless habitat connectivity between the two lakes. Piscicide treatment would occur after physical methods eradicated fish from the upstream lake habitat (~2028).
		Slide	*R. sierrae*	Current fishless habitat is limited to a set or peripheral ponds, streams and one lake disconnected from each other by one fish-containing lake and connected streams in the core of the basin. All fish removal can be completed using physical methods.
		Swamp	*R. sierrae*	Current fishless habitat in this branch of the basin is limited to one lake in the upper part of the basin disconnected from the lower part of the basin by one fish-containing pond and connected stream sections. All fish removal can be completed using physical methods.
		Horseshoe	*R. sierrae*	Current fishless habitat is limited to a set of peripheral lakes and ponds disconnected from each other by four fish-containing lakes and streams that are the largest lakes the basin. Once physical restoration is completed in the lakes (~2032), piscicides may be needed to remove all remaining fish from the outlet stream channels, due to a long stream section before reaching the definitve fish barrier.
		Upper Kern	*R. muscosa*	Current fishless habitat is limited to a set of peripheral lakes, ponds and streams disconnected from each other by a large complex of interconnected fish-containing habitat in the geographic center of the basin. Physical methods would eradicate fish from some of the upstream lake habitat (~2034), after which piscicides would be needed to eradicate fish from the rest of the treatment area. Piscicide treatment would only commence after re-evaluation of the area to confirm a definitive fish barrier exists at the downstream end of the treatment area.

Table 12 continued.

Priority Tier	Estimated Years of Treatment	Site Name	MYLF Species	Rationale
3	2036-2045	Rambaud	*R. sierrae*	Current fishless habitat is limited to lakes in the lower and upper parts of the basin disconnected from each other by one fish-containing pond and connected stream section. All fish removal can be completed using physical methods.
		Upper Bubbs (Forester)	*R. muscosa*	Current fishless habitat is limited to a set of peripheral lakes, ponds, and streams disconnected from each other by a complex of interconnected fish-containing habitat in the core of the basin. All fish removal may be feasible for eradication using physical methods.
		East Wright	*R. muscosa*	Current fishless habitat in this branch of the basin is limited to lakes and streams in the upper part of the basin, which is disconnected from the lower part of the basin by one fish-containing lake and connected stream sections. All fish removal can be completed using physical methods.
		Blossom	*R. muscosa*	Current fishless habitat is limited to a set or peripheral ponds disconnected from each other by two fish-containing lakes and streams that are the largest lakes in the basin. All fish removal can be completed using physical methods.
		Tablelands	*R. muscosa*	Current fishless habitat is limited to lakes, ponds, and streams in the upper parts of two branches of the basin, which are disconnected from each other and the lower part of the basin by one fish-containing pond, connected stream, and marshy sections. All fish removal can be completed using physical methods.

Table 13. **Estimated timeline of piscicide fish eradication treatments under alternative B.**

In general, priority tier 1 would be implemented before priority tier 2, and priority tier 3 would be implemented last. Actual implementation sequence would depend on urgency related to completing physical eradication habitats, complexity of piscicide treatment habitat, MYLF habitat restoration need, funding, logistics, and weather. The "MYLF Species" column shows the range of MYLF in which each basin is located. Fish eradication would create an interconnected network of fishless habitat that would benefit all native species, including federally endangered MYLFs. Restoration is needed in all proposed basins to provide large, deep lakes and/or a diverse array of quality habitat for sustaining more robust populations of native species. Additionally, proposed restoration would provide aquatic habitats better able to withstand drying and warming expected with climate change.

Priority Tier	Estimated Years of Treatment	Site Name	MYLF Species	Rationale
1	2017 - 2026	Amphitheater	*R. sierrae*	Piscicide use is needed because the treatment area includes a large lake and two long outlet streams before reaching the definitive fish barrier. It is ready for treatment.
		Sixty Lake	*R. muscosa*	Piscicide use is needed to help complete at least two existing physical fish removal lakes, where insufficient cascades are allowing fish to pass and preventing eradication. Piscicide use is needed because the treatment area includes a complex of interconnected lakes, ponds, and streams before reaching the definitive fish barrier. The site is ready for piscicide treatment.
		Upper Bubbs	*R. muscosa*	Fish eradication is needed to connect two distant physical fish removal lakes, and to help complete one of these lakes, where an insufficient cascade is allowing fish to pass, which prevents complete eradication. Piscicide use is needed because the treatment area includes a long and large stream section between the edge of the lake basin and the definitive downstream fish barrier. This site would be ready for piscicide treatment after physical methods eradicated fish (~2020).
		Laurel	*R. muscosa*	Piscicide use is needed because the treatment area includes two long streams and connecting marshy areas before reaching the definitive fish barrier. It is ready for treatment.
		Upper Evolution	*R. sierrae*	Piscicide use is needed because the treatment area includes long stream sections of complex habitat (shallow, cobbles, braids, marshy) before reaching the definitive fish barrier. This site would be ready for piscicide treatment after physical methods eradicated fish from the upstream lake habitat (~2025).
2	2027 - 2035	Crytes	*R. muscosa*	Piscicide use is needed because the treatment area includes two long streams and connecting marshy areas before reaching the definitive fish barrier. It would be ready for piscicide treatment after physical methods eradicated fish from the upstream lake habitat (~2028).
		Horseshoe	*R. sierrae*	Piscicide use is needed because the treatment area includes a long stream section before reaching the definitive fish barrier. It would be ready for piscicide treatment after physical methods eradicated fish from the upstream lake habitat (~2032).
		Upper Kern	*R. muscosa*	Piscicide use is needed because the treatment area includes a complex of interconnected lakes, ponds, and streams. It would be ready for piscicide treatment after physical methods eradicated fish from some of the upstream lake habitat (~2034), and if re-evaluation of the area confirms a definitive fish barrier exists at the downstream end of the treatment area.
3	2036	Crescent	*R. muscosa*	Piscicide use is needed because the treatment area includes a long complex of interconnected streams and marshy areas before reaching the definitive fish barrier. It is ready for piscicide treatment now, but due to potential vulnerability of this mid-elevation habitat to drying and warming expected under climate change, waiting allows confirmation that this habitat would persist before conducting a piscicide treatment.

Physical Treatment Methods

Gill-Netting

Gill-netting (Photo 1) is a method of fish collection that is primarily used in lakes, ponds and stream pools. Repeated gill-netting has been successfully used to completely remove fish from lakes (Knapp and Matthews 1998, Knapp et al. 2007, NPS 2012A). The gill-nets used for nonnative fish removal in SEKI 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.

Photo 1. Physical Treatment - Gill netting

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 between net checks 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.

To minimize the capture of amphibians, the shore ends of gill-nets are generally set approximately 3 to 10 ft (1 to 3 m) from shore. This provides an area where amphibians on and near the shoreline can be active with lower potential for getting caught in a net. Areas observed to periodically contain many tadpoles and frogs are avoided when placing gill-nets because tadpoles and post-metamorphic frogs can occasionally be captured in nets. Based on previous restoration work, MYLFs have constituted about 0.5% of all gill-net captures (NPS unpublished data).

Once a site is completed, gill-nets are decontaminated and reused for fish eradication at other sites. All gill-nets would be decontaminated in a bath of diluted quat-128 (active ingredients Didecyl dimethyl ammonium chloride [5%] and n-Alkyl dimethyl benzyl ammonium chloride [3%]) to remove potential pathogens, rinsed with fresh water, and set in the sun to dry before being used in any new locations. If decontamination occurs in the field, diluted quat-128 and water baths would be used more than 100 feet from any water source and discarded in organic matter, per SEKI decontamination protocols.

Electrofishing

Electrofishing (Photo 2) is a physical method of fish collection primarily used in streams and occasionally in shallow water at the edges of lakes. It 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 and experience involuntary muscle contractions that attract the fish toward the anode (this is known as galvanotaxis), at which point the fish are more easily captured using dip nets.

Photo 2. Physical Treatment - Electrofishing

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. Captured fish would be euthanized using compression fracture of the skull (Carmona-Catot et al. 2010) and carcasses would be disposed in nearby lentic waterbodies.

Although a successful method for eradicating fish in certain habitats, electrofishing is labor intensive and fish eradication using this method often takes many years of consistent effort. Electrofishing requires repeated passes through each target stream section throughout each field season (approximately June–September). If electrofishing is undertaken in concert with fish removal via gill-nets in connected lentic habitats, efforts must continue until fish have also been eradicated from the adjoining lakes and ponds in the restoration area. These physical methods are costly and difficult, but they have proven successful in many areas (e.g., Kulp and Moore 2000, Vredenburg 2004, Knapp et al. 2007).

Fish Traps

Fish traps (Figure 8) 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. During the first field season, traps would be set during ice-out and removed following spawning activity. Traps would be checked regularly to remove fish, release nontarget captures, and clear debris. Following the first field season, the effectiveness of having the traps deployed would be assessed. If the traps were not effective then traps would not be deployed. If the inlet or outlet stream is wider than the trap (1.6 ft / 0.5 m) then mesh arms made out of PVC pipe and aquaculture mesh would be used to construct a funnel between the trap and the stream bank.

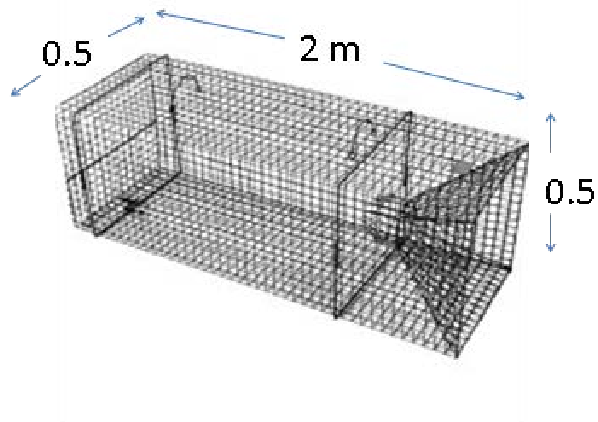

Figure 8. Diagram of a fish trap

Disruption and/or Covering of Redds
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.

<u>Piscicide Treatment</u>
A piscicide is a substance that is toxic to fish and whose intended function is to eliminate undesirable fish from a body of water (CDFW 2007). Two piscicides have been widely used by fishery managers to eliminate trout species - rotenone (derived from plants) and antimycin A (derived from bacteria). In 2007, following ecological and human health risk assessments conducted by U.S. Environmental Protection Agency (EPA), both were declared eligible for reregistration as restricted-use piscicides (EPA 2007A, 2007B). Rotenone was then reregistered by the CDPR for applications targeting fish in California waters. The Prentox CFT Legumine™ formulation of rotenone is currently registered with CDPR for use in aquatic environments for the purpose of fish removal (CDPR 2016).

Since the CFT Legumine™ formulation of rotenone is currently the only piscicide registered for use in California, it is the only proposed piscicide treatment evaluated in this plan. If another piscicide becomes available for use in California, NPS staff may assess the appropriateness of its use in SEKI to accomplish the purpose, goals, and objectives of this plan. If undertaken, this assessment would include opportunities for public review and involvement, and would comply with existing laws, policies, and plans. For more information on piscicides, see appendices G and H.

Detailed piscicide treatment protocols are included as appendix N. In summary, piscicide treatments in this Restoration Plan/FEIS follow guidance and standard operating procedures documented in *Planning and Standard Operating Procedures for the Use of Rotenone in Fish Management* (Finlayson et al. 2010A) and project plans in NOCA (NPS 2015C) and Silver King Creek, California (FWS 2010). Piscicide application 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. Experienced piscicide applicators would be directly involved in piscicide treatments in SEKI, and all treatments would be managed by applicators certified by CDPR to apply piscicides in state waters. Though not a requirement for federal land managers, this certification would ensure applications are correct and best management practices are applied during treatment activities.

Piscicide applications in this plan would be conducted with an intention of eradicating all fish at treatment sites. A goal is to achieve eradication using as few treatments as possible. Fish eradication would likely be accomplished after one or two treatments at each site. Several treatments have recently been conducted in NOCA, YELL, GRSM, and GRBA in which one application eradicated all fish. A third treatment may be necessary in the most complex areas, including Sixty Lake, Upper Kern and Laurel. Complex habitats increase the chances that rotenone concentrations would not reach levels lethal to fish in all areas (Finlayson et al. 2010A). This rotenone SOP recommends spacing out treatments in time (usually so they occur over the course of multiple years) to allow fish eggs sufficient time to hatch and fry to be vulnerable to rotenone exposure. Spacing out treatments over time (e.g., one treatment per year over two or three years) also allows time for different environmental conditions to occur, which could change the conditions under which fish are exposed (Finlayson et al. 2010A). The variability in treatment conditions may help target fish that were not exposed to lethal doses of rotenone during earlier treatment.

The general protocol would be to treat habitat once in mid-late summer, monitor in September, and monitor again in the following early to mid summer. If live fish are found, a second treatment would be conducted. If no live fish are found, then a second treatment would not be necessary. Some of the proposed treatment areas in SEKI are small (e.g., one outlet stream of Upper Bubbs) and one treatment has a good probability of eradicating all fish in these areas. Other proposed treatment areas are larger (e.g., lower watershed of Sixty Lake), and while one treatment may eradicate all fish in these areas, additional treatment(s) may be necessary. Whether reapplications may be necessary in a treatment area is based on several site-specific factors, such as fish species, habitat size and complexity, streamflow and gradient, water temperature, water quality, and others. If fish eradication is unsuccessful after three treatment years (initial year plus two reapplication years) at a particular site, then piscicide use would be abandoned at that site.

Each individual piscicide treatment would require up to ten working days (approximately 1½ weeks) including mobilization, application, neutralization, and demobilization. A crew of 8 to 15 people is needed to implement most of the piscicide treatments due to the greater size, complexity, and number of tasks compared to physical treatments. A crew of more than 15 people may be needed to implement one or more of the largest piscicide treatments, including Sixty Lake, Upper Kern and Laurel. Personnel experienced in piscicide treatments from other NPS units and/or CDFW would lead the first one to two treatments, after which SEKI personnel are expected to be sufficiently trained to lead the remaining treatments.

Clear definitions of the ‘project area’ and ‘treatment area’ are helpful for ensuring that piscicide treatment projects are successful. The project area for each treatment basin includes the treatment area, areas closed to public access during the treatment, locations where CFT Legumine™ would be mixed and measured, downstream fish barriers, and the deactivation site. The treatment area comprises the water bodies or portions thereof, into which CFT Legumine™ is applied.

ALTERNATIVE C: PHYSICAL TREATMENT PRECEDING RESTORATION

Alternative C would use physical treatment methods only to eradicate nonnative fish. The physical treatment methods include gill netting, electrofishing, trapping, disruption and/or covering of redds, and blasting rock to create vertical fish barriers. In comparison to alternative B, excluded from the list of proposed restoration waters are long reaches of stream, most large lakes (which are more resistant to climate change), and interconnected lake complexes that are too large or complex for effective physical treatment. Under this alternative, a prescription for restoration would be developed for each proposed restoration area based on the criteria for basin selection, pre-treatment surveys, habitat size, basin topography, wilderness values, visitor use, field crew safety, and the actual distribution of fish and amphibians.

Physical treatment methods would be used in 52 waterbodies (27 lakes, 24 ponds, 1 marsh; total of 492 ac/199 ha) and approximately 15 mi (25 km) of stream in 17 basins (Table 14 and Figure 9). 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 site specific prescriptions, the number of waterbodies and stream miles identified for treatment represents the maximum number of waterbodies 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 51 basins, as indicated in detail by purple (physical treatment waterbodies) in Figure 9 and orange dots (basins with fishless habitat important for conservation of native species) in Figure 6. Nonnative fish would be eradicated using physical methods only from 52 waterbodies in 17 basins, including 51 lakes and ponds (491 ac/199 ha), 1 known fish-containing marsh area (1 ac/0.4 ha), approximately 15 mi (25 km) of streams, plus additional connecting fish-containing habitat as necessary. These 52 waterbodies represent 9% of the parks' approximately 550 waterbodies 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 17 fish eradication basins, plus 34 additional basins where no fish eradication would occur (Table 7, Figure 5 and Figure 6).

Development of the Treatment Plan
The precise areas to be treated would be determined following a survey of each proposed restoration site. These surveys would be less intensive than surveys needed for piscicide treatment because physical treatment methods have minimal effects on non-target animals. Information needed to develop the treatment plan includes precise information on the distribution of fish and amphibians, need for and potential location of fish barriers, habitat characteristics (i.e. open water, aquatic and riparian vegetation), and basin characteristics (i.e. stream gradients, lake size/depth, channel characteristics, and connectivity between sites). Physical treatment prescriptions would be developed prior to treatment and approved by the parks' superintendent or their designee.

Proposed Treatment Methods
Under this alternative, only physical treatment would be used to eradicate nonnative fish prior to restoration. The physical treatment tools would consist of gill nets, electrofishers, fish traps, disruption and/or covering of redds, and blasting of rock to create vertical fish barriers. The description of all of these physical treatment methods except for blasting are the same as described under alternative B. The description of blasting follows.

Blasting Rock to Create Vertical Fish Barriers
Blasting of rock (if necessary to create vertical fish barriers) may be used to augment gill netting, electrofishing, fish trapping, and redd disruption and/or covering efforts. Fish barriers are needed at the downstream boundary of each treatment area to prevent nonnative fish in downstream waterbodies from recolonizing a treatment area. For most areas, natural cascades or waterfalls are of sufficient height and slope to act as fish barriers [i.e., vertical waterfall or near-vertical cascade at least 5 to 6 ft tall (1.5 to 1.8 m)]. However, there may be rare situations where a cascade is tall enough but not steep enough to prevent

fish from recolonizing a treatment site (crews can easily detect fish recolonization). If this occurs, blasting could be used in stream to modify an existing cascade to create a vertical or near-vertical waterfall that would function as a barrier to fish passage. This would be accomplished by blasting the downstream portion of rock, leaving a steep cascade or waterfall high enough to prevent fish from recolonizing the upstream treatment area. The resulting bedrock barriers would not need long-term maintenance and would largely appear natural to most visitors. Blasting has been used successfully in the region to create fish barriers (McGuire C., pers. comm., 2004).

The modification of streams by blasting would require the NPS to complete site-specific surveys to determine if blasting is feasible, and to address potential effects on natural and cultural resources. In addition, all applicable state and federal permits would be obtained. This surveying and permitting would be completed on a case-by-case basis before activities are commenced.

Table 14 lists all basins proposed for nonnative fish eradication under alternative C, including the number of lakes, ponds and stream miles per basin using physical treatment only. Not included in this table is one known fish-containing marsh (0.86 ac/0.4 ha) located in the Tablelands that is also proposed for nonnative fish eradication using physical treatment.

Table 14. Basins and waterbodies proposed for nonnative fish eradication under alternative C

Basin	# Lakes	Area (ac)	# Ponds	Area (ac)	Stream (mi)
Physical Treatment Only					
Barrett	3	42.07	1	0.28	0.87
Blossom	2	9.45	2	2.29	0.64
Brewer	0	0.00	1	1.60	0.52
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	28.96	0	0.00	0.40
McGee	4	75.31	4	1.19	1.20
Milestone	1	12.80	1	2.07	0.49
Rambaud	0	0.00	1	0.44	0.25
Slide	1	5.12	1	0.17	1.60
Swamp	0	0.00	1	1.85	0.28
Tablelands	0	0.00	1	1.48	1.65
Upper Bubbs	2	21.62	2	1.67	4.32
Upper Evolution	4	228.19	1	0.48	1.20
Upper Kern	0	0.00	2	2.12	0.38
Vidette	2	16.57	3	0.23	0.39
Grand Total	**27**	**473.91**	**24**	**17.34**	**15.58**

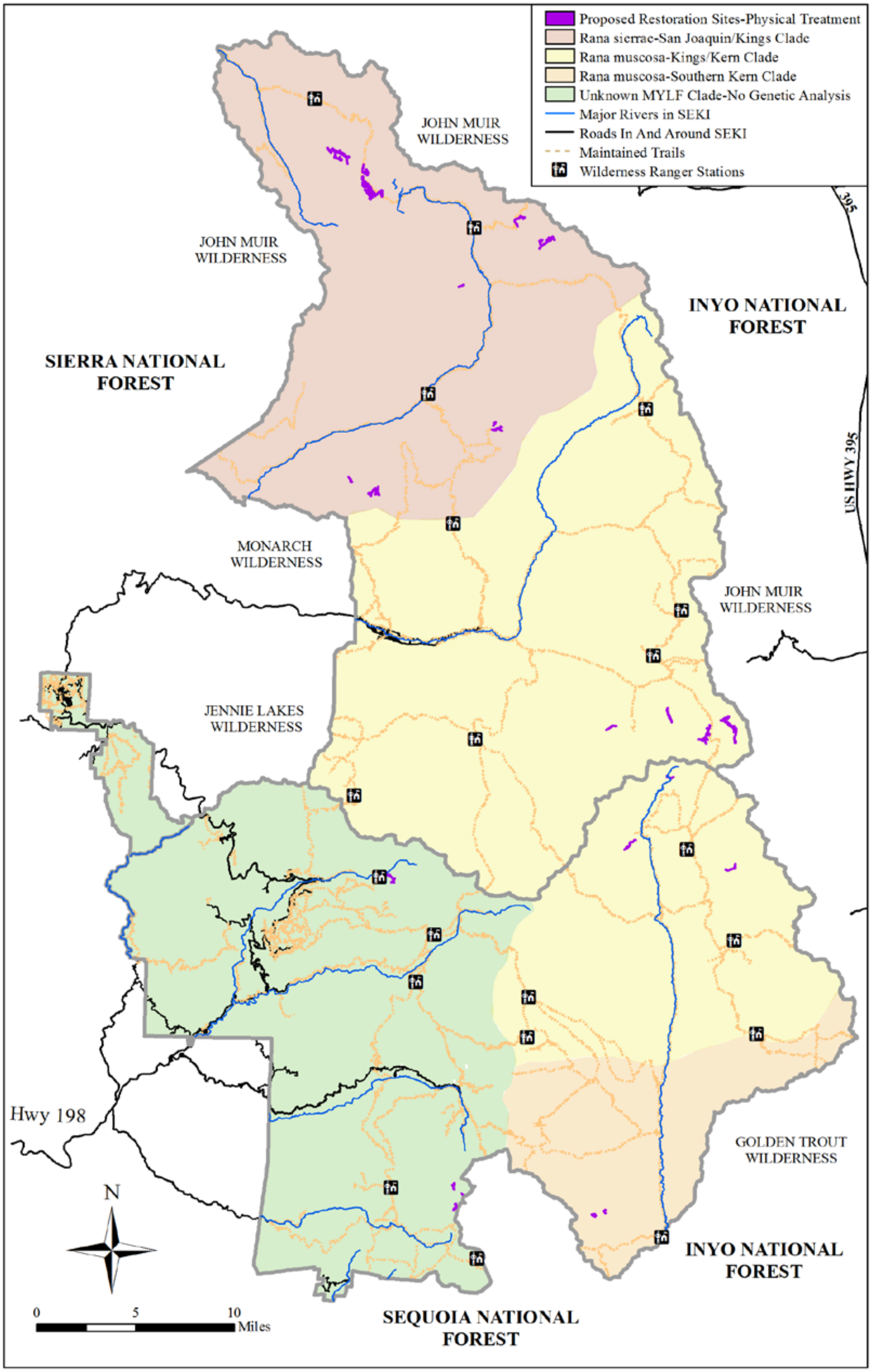

Figure 9. Map of basins proposed for nonnative fish eradication under alternative C
Physical treatment waterbodies and streams are shown in purple.

ALTERNATIVE D: PISCICIDE TREATMENT PRECEDING RESTORATION

Alternative D emphasizes speed in recovering habitat due to the critical status and ESA listing of MYLFs. MYLF populations are declining rapidly and are at risk of becoming extinct in the near term. To achieve this speed, only piscicide treatment would be used for nonnative fish eradication. Properly applied, piscicides can eliminate fish from targeted waterbodies in as few as one to two days per site, in contrast to physical treatment which can take up to six years for lakes and up to 10 years for streams (NPS 2012A). A prescription for treatment would be developed as described in alternative B. Based on initial examination of maps, staff familiarity with the parks, and discussions with experts, piscicide treatment would be used for 85 waterbodies (31 lakes, 49 ponds, and 5 known fish-containing marshes; total of 634 ac/257 ha), approximately 31 mi (50 km) of streams, plus additional connected fish-containing habitat as necessary (Table 15, Figure 10). Although the total acreage requiring treatment may change slightly based on site-specific survey information and treatment plan development, the number of waterbodies and stream miles identified for treatment represents the maximum number of waterbodies to be treated in this alternative. If selected, piscicide treatments would occur starting in 2017, at the earliest.

Location of Proposed Treatments
Aquatic ecosystem restoration would take place in 55 basins (Table 7, Figure 5 and Figure 6), as indicated in detail by yellow (piscicide treatment waterbodies) in Figure 10, and orange (fishless waterbodies important for conservation of native species) in Figure 5. Nonnative fish would be eradicated using piscicide methods from selected waterbodies in 21 basins, including 85 lakes and ponds (602 ac/244 ha), 5 associated fish-containing marsh areas (32 ac/13 ha), approximately 31 mi (50 km) of stream, plus additional connected fish-containing habitat as necessary. These 85 waterbodies represent 15% of the parks' 550 waterbodies 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 21 fish eradication basins (Table 15, Figure 10) plus 34 additional basins (Table 7, Figure 5 and Figure 6) where no fish eradication would occur. All project locations addressed in this alternative are in designated wilderness, with the exception of Crescent Basin.

Development of the Treatment Plan
Site-specific piscicide treatment plans would be developed during years immediately prior to treatment so that the information would be current when the treatment begins. The precise area to be treated would be determined following a thorough survey of each site. Information needed to develop each piscicide treatment prescription would include precise information on the distribution of fish and amphibians, need for and potential location of fish barriers, invertebrate surveys, habitat characteristics (i.e. open water, aquatic and riparian vegetation), and basin characteristics (i.e. stream flow/gradients, lake size/depth, channel characteristics, connectivity between sites, and unique aquatic environments).

Proposed Treatment Methods
Under alternative D, all waterbodies proposed for nonnative fish eradication would be treated with piscicides registered for use in California prior to restoration. Currently the only piscicide registered in California is rotenone. The piscicide formulation used for restoration and the application would be the same as is outlined in alternative B. Under this alternative, physical treatment methods would not be used unless a unique situation was encountered where a physical treatment technique would actually be faster or more appropriate than piscicide treatment. For example, 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 invertebrate source population. Every effort would be made to avoid treating fishless areas and to maintain upstream

source populations of invertebrates for repopulating treated areas. In some cases, this could involve a physical treatment at the head of a stream and installation of a temporary fish barrier. The description of piscicide treatment methods is the same as described under alternative B.

Table 15 lists all basins proposed for nonnative fish eradication under alternative D, including the number of lakes, ponds and stream miles per basin using piscicide treatment only. Not included in this table are five known fish-containing marshes (totaling 32.42 ac/13.1 ha) that are also proposed for nonnative fish eradication using piscicide treatment, including one marsh (8.63 ac/3.5 ha) located in Crytes, three marshes (totaling 22.26 ac/9 ha) located in Laurel, and one marsh (0.86 ac/0.4 ha) located in the Tablelands.

Table 15. Basins and waterbodies proposed for nonnative fish eradication under alternative D

Basin	# Lakes	Area (ac)	# Ponds	Area (ac)	Stream (mi)
Piscicide Treatment Only					
Amphitheater	1	58.87	2	1.34	2.16
Barrett	3	42.07	1	0.28	0.87
Blossom	2	9.45	2	2.29	0.64
Brewer	0	0.00	1	1.60	0.52
Crescent	0	0.00	0	0.00	1.58
Crytes	2	20.62	1	0.87	2.00
Dusy	1	10.58	2	0.60	0.69
East Wright	1	2.63	0	0.00	0.66
Horseshoe	4	28.96	0	0.00	3.39
Laurel	0	0.00	1	0.22	3.09
McGee	4	75.31	4	1.19	1.20
Milestone	1	12.80	1	2.07	0.49
Rambaud	0	0.00	1	0.44	0.25
Sixty Lake	1	13.36	14	14.87	1.00
Slide	1	5.12	1	0.17	1.60
Swamp	0	0.00	1	1.85	0.28
Tablelands	0	0.00	1	1.48	1.65
Upper Bubbs	2	21.62	2	1.67	5.25
Upper Evolution	4	228.19	1	0.48	1.68
Upper Kern	2	18.32	10	6.29	1.85
Vidette	2	16.57	3	0.23	0.39
Grand Total	**31**	**564.46**	**49**	**37.95**	**31.27**

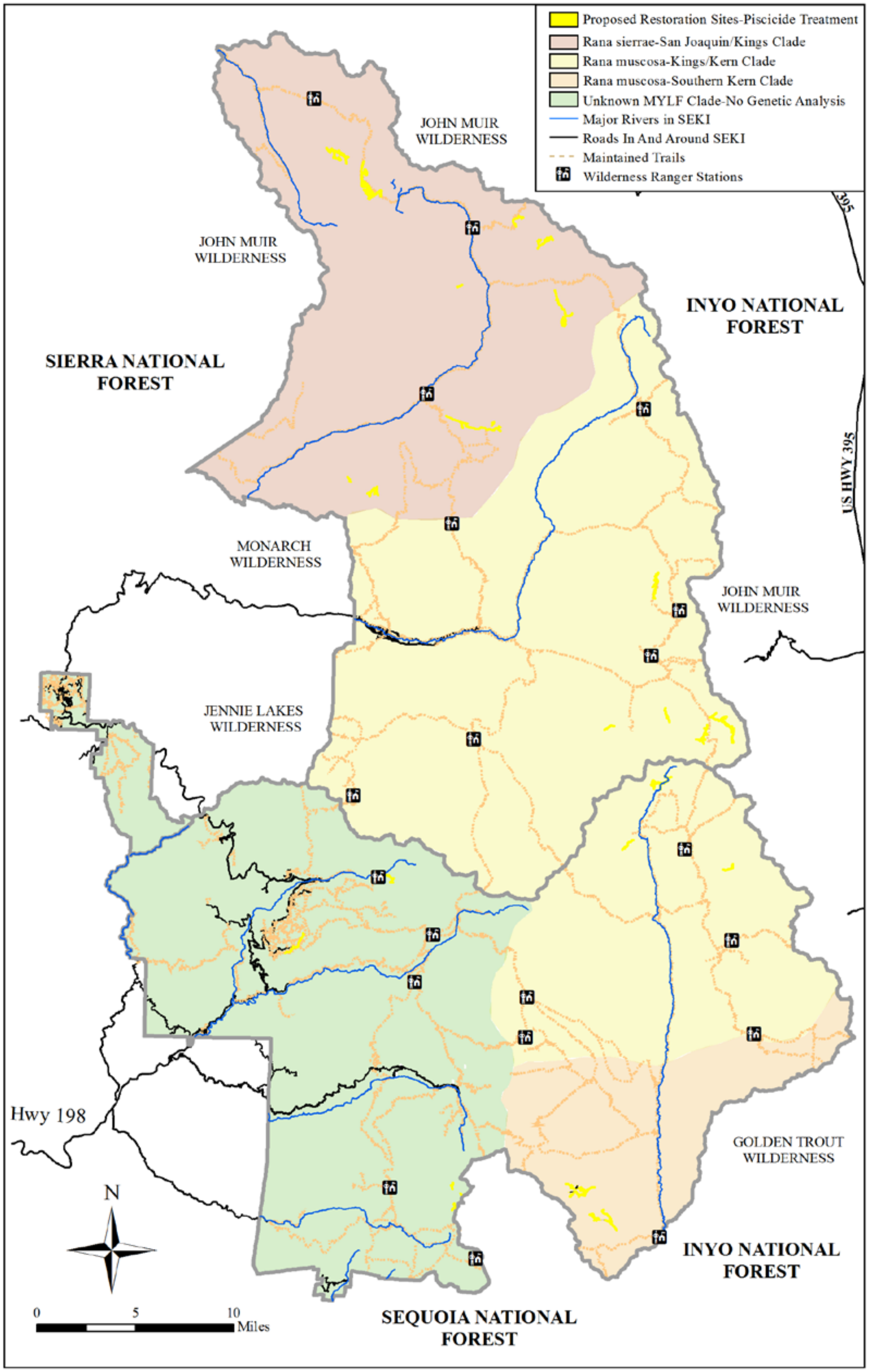

Figure 10. Map of basins proposed for nonnative fish eradication under alternative D
Piscicide treatment waterbodies and streams are shown in yellow.

MITIGATION MEASURES COMMON TO ALL ALTERNATIVES

Mitigation measures are designed to prevent or minimize adverse impacts or to contain impacts within acceptable limits during and after project implementation. In addition to the mitigation and best management practices described under each alternative, the following mitigation measures would be implemented for all action alternatives. The environmental consequences of the alternatives (chapter 4) are evaluated with the assumption that the following mitigations would be implemented as part of any action alternative.

Work Crews

- All crews would be instructed in and expected to use minimum impact camping practices and wilderness ethics.
- Crew camps would 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 would be avoided, but would 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 ft (30 m) from any surface water and would be poured into a small pit through a screen to remove small food particles. Strained food particles are removed from the area 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

- SEKI’s packstock operations would be subject to the same minimum impact standards and grazing regulations as general parks users.
- 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. Where grazing is not allowed, only supplemental feed products that have been either heat treated or fermented so as to render any weed seeds inviable would be fed to stock.

Helicopter Use

- A helicopter would be used only if determined through the minimum requirement analysis to be the minimum tool necessary for a particular project and project site.
- 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.
- No whitebark or foxtail pines may be cut to accommodate a landing zone.
- 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 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.
- No helicopter fuel would be stored in wilderness. All helicopter fuel and other supplies not needed on the helicopter during flights would be stored at the frontcountry Ash Mountain Helibase.

Restoration of Mountain Yellow-legged Frogs

- All personnel involved in collection and handling for CMR, translocations, reintroductions, antifungal treatments, and any other methods that involve handling MYLFs would be professional biologists with years of experience with proper handling of endangered amphibians, or–for trained, but less experienced biologists–work under the direct supervision of professionals.
- Handlers would have wet hands when handling any listed amphibian. No adults in amplexus (mating behavior) would be handled during routine monitoring and research activities.
- MYLF handling would be kept to the minimum time necessary for effectively completing conservation actions.
- Expeditious and cautious handling, including proper climate control, would be used during translocations and reintroduction efforts, including transport out of the wilderness, travel time to captive rearing facilities, and transport back to wilderness following captive-rearing.
- All captive-rearing efforts would be undertaken by professional biologists and/or captive rearing facility staff experienced with animal care and disease management techniques.
- Collections would be limited to the minimum number of animals necessary to successfully complete recovery actions and FWS would be consulted to obtain the proper permits.

Vegetation

- Prior to initiating work, project work areas and crew camp sites would be surveyed for the presence of plant species of concern.
- 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 (2) 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 0.5 mi (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.
- All personnel involved in garter snake relocation would be professional biologists with years of experience with proper handling and marking of snakes, or–for trained, but less experienced biologists–work under the direct supervision of professionals.
- Handling of garter snakes for relocations would be kept to the minimum time necessary for effectively completing each relocation action.

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.
- Secondary containment for hazardous materials (e.g. piscicide or white gas) would be incorporated by placing buckets containing a small amount of soil (to minimize splashing of possible spills) under transfers of materials from one container to another. If hazardous materials were nevertheless spilled, they would be cleaned up immediately and would not be allowed to seep deep into the soil or reach open water sources. Absorbent pads would be onsite to absorb pooled hazardous materials. Shovels and bags would be onsite to gather surface soil in the spill area, which would be transported to the frontcountry for remediation.
- 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' disturbance from 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 would be immediately stopped. The parks' archeologist or a qualified representative would examine the area as soon as possible and would 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 wilderness safety and 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 any restoration activities.
- While gill-netting, crewmembers would wear waterproof chest waders, safety waist belts, personal floatation devices (PFDs), and flip fins to remain warm and dry while using float tubes.
- For electrofishing, crewmembers would wear waterproof chest waders and gloves that do not conduct electricity.
- For electrofishing and disturbing/covering trout redds, crewmembers would wear wading boots with felt-lined soles that provide improved stability.
- While installing and monitoring fish traps, crewmembers would wear wading boots with felt-lined soles that provide improved stability, and gloves to protect their hands while working with the traps.
- Parks staff involved in blasting activities would wear appropriate PPE (head, eye, ear, and hand protection) and perform their work according to SEKI's blasting procedures. Charges are activated using detonation cord, allowing staff to position themselves safely away from the blast area.

Visitor and Crew Safety During Piscicide Treaments:

- Experienced piscicide applicators would be directly involved in piscicide treatments in SEKI, and all treatments would be managed by applicators certified by CDPR to apply piscicides in state waters. Though not a requirement for federal land managers, this certification would ensure applications are correct and best management practices are applied during treatment activities. All of the restoration crew working with piscicides would be trained in proper use of PPE, 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 PPE for applicators, controlling public access during application, determining the maximum necessary application concentrations, and all other applicable guidelines.
- 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, (5) staff at local wilderness permit stations, (6) temporary postings to the parks website and (7) 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.

Mitigations Specific to Treatment Type
The mitigations for specific types of treatment options are described below. These mitigations would be implemented based on the methods selected in the final plan.

Gill Netting

- 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.
- Crew members without direct experience with handling non-target wildlife would receive training from an experienced biologist in how to safely remove non-target wildlife from nets.
- 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. Areas observed to periodically contain many tadpoles and frogs would generally be avoided when placing gill nets.

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.
- The output from electrofishers is engineered to specifically target fish so few non-target species would be affected by electrofishing. Neveretheless, during electrofishing, crews continually scan the area in front of their progress for non-target wildlife including mountain yellow-legged frogs. If a non-target species is observed, the electrofisher is turned off until the animal leaves the water or the shocking area. If necessary, crews capture and move the animal downstream or to adjacent terrestrial habitat and then proceed with electrofishing.

Disruption and/or Covering of Redds

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

Fish Traps

- While installing and monitoring fish traps, crewmembers would 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

- 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.

Piscicide Use

- Although very few, if any, amphibians (MYLFs, Yosemite toad, Pacific treefrog) of any life stage are typically present in fish-containing areas, any post-metamorphic frogs or tadpoles observed that can be captured by hand, dip net and/or seine would be removed from the piscicide treatment area and placed in a nearby fishless waterbody disconnected from the treatment area while piscicide concentrations dissipate.
- 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.
- 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 upstream 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 have their swim bladders punctured so the carcasses would sink to the substrate.
- 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 were 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 and rotenolone concentrations as well as for volatile organic compound and semi-volatile organic compound concentrations because CFT Legumine™ contains petroleum distillates.
- 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 all contaminated 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.

- 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 eight to 15 people is expected to be sufficient to implement most treatments, and a crew of up to 16 to 25 people may be needed for one or more of the largest piscicide treatments.
- 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 would be avoided. Treatment activities would be coordinated with wilderness management personnel.
- To incorporate the results of actual piscicide treatments in SEKI to future treatments, an adaptive management approach would implemented, in which intensive monitoring of the initial piscicide treatments is used to better describe the likely impacts of subsequent treatments, and if necessary, to redesign subsequent treatments to further minimize anticipated impacts.

Terms and Conditions from the Biological Opinion (Appendix L)

In order to be exempt from the prohibitions of section 9 of the Endangered Species Act, the NPS must ensure compliance with the following terms and conditions, which implement the reasonable and prudent measure described above. These terms and conditions are nondiscretionary.

1. The NPS shall implement the Conservation Measures as described in the biological opinion.

2. Mountain yellow-legged frog surveys, including capture and handling for measurements and examining for infections, shall follow the guidelines found in Knapp and Matthews (2000) as revised during the life of this project, or other guidelines as authorized by the FWS.

3. The use of PIT-tagging and the injection of colored elastomers are authorized to mark individual mountain yellow-legged frogs, and shall be implemented in the following manner:

    a. No mountain yellow-legged frogs less than 4 centimeters snout-vent length (SVL) shall be PIT-tagged. PIT tags of appropriate size shall be used (8-12 mm).

    b. Crews shall note any physical or behavioral changes to individual mountain yellow-legged frogs that could possibly be attributed to the insertion of PIT tags or injection of colored elastomer, such as swelling, bleeding, infection, or changes in swimming ability. This information shall be included in the annual reports.

    c. Tissue samples for genetic research may be collected from tadpoles or adult mountain yellow-legged frogs. Tissue samples may be collected from swabbing the skin surface. Alternatively, for genetic research that may require a larger individual sample, clipping of a single toe from post-metamorphs to obtain tissue samples shall be allowed with the use of surgical scissors only.

4. Collection of individual mountain yellow-legged frogs for examination and treatment of infectious disease.

    a. All captured individual mountain yellow-legged frogs may be examined, swabbed for determining the presence of infectious disease, and treated if a known or experimental treatment is available. Dead or moribund individual mountain yellow-legged frogs should also be swabbed, if practical, to determine cause of death.

b. If individual mountain yellow-legged frogs are found to have signs of infection or determined to be infected by chytrid fungus (chytridiomycosis), they may be treated using itraconazole. Individuals may be retained in specially designed cages at the collection site for up to two weeks while being treated. Treatment method may vary; however, the field crew must have suitable experience conducting the treatment method.

5. For the captive rearing and translocation program:

   a. All collection, transport, captive care, and release activities will follow the associated methods and protocols specified in the translocation plan as described in Knapp *et al* (2011) and the Conservation Strategy (Knapp, Appendix A *in* FWS in preparation). Any deviation from these methods and protocols requires prior approval from the FWS.

   b. The NPS, and all captive rearing facilities, shall assure to the maximum extent practicable that all individuals removed will not contract a disease, unless that is part of the immunization procedure for disease treatment. Potential threats to the mountain yellow-legged frog regarding the introduction and/ or spread of disease shall be closely monitored.

   c. Only individuals removed from the wild for captive rearing that are sick, injured, or have no reasonable prospect of being reintroduced to the wild may be euthanized for scientific research and vouchering of specimens, or if deemed fit enough, used for display or public outreach by the holding facility.

   d. The San Francisco Zoo, Oakland Zoo, or other facility authorized by the FWS may receive mountain yellow-legged frogs for captive rearing and husbandry pursuant to the Biological Opinion. The following measures shall be implemented by the facility(ies).

      i. All proposed captive rearing activities for the upcoming season will be submitted in writing for review and approval by the FWS and the California Department of Fish and Wildlife. The FWS will be notified via email within 24 (24) hours following delivery of individual mountain yellow-legged frogs to the captive facility(ies). Notification will include numbers and lifestages of individuals delivered, condition and status of individuals, and collection location. In emergency situations, injured individuals shall be delivered first to a qualified veterinarian or FWS approved biologist.

      ii. The number of individual frogs taken into captivity annually will not exceed the capacity of the facility(ies) to provide adequate care and husbandry as determined by the FWS.

      iii. Individuals will be transferred to the captive facilities and returned to the wild using appropriate methods to avoid and minimize harassment, death and injury to the animals. Carrier containers shall keep the individual individuals cool, adequately hydrated, and free from injury or death due to contact with protruding or sharp objects within the interior.

      iv. Incoming individuals displaying signs of any infectious pathogens shall be immediately separated upon observation and kept physically isolated (quarantined) from any living amphibians residing in the facility(ies), including mountain yellow-legged frogs from other locations. Infected individuals will be treated by a veterinarian, or by a qualified technician under instruction of a veterinarian, until the individual is evaluated as free of the infection.

v. Individuals will be held in an American Zoological Association-approved tank or natural display.

vi. Once in captivity, individual frogs will not, under any circumstances, be bred in captivity without the written permission of the FWS.

vii. All handling shall be done in an expedient manner with minimal harassment and injury to the individuals being handled. The hands and arms of all workers handling frogs shall be free of lotions, creams, sunscreen, oils, ointment, insect repellent, or any other material that may harm frogs.

6. For emergency salvage of mountain yellow-legged frogs:

   a. Only pools that have been determined to be unable to continue supporting eggs or tadpoles until the wet season shall be considered for salvage actions. These pools shall be monitored by SEKI field crews to determine drying rates and assess predation pressures. The NPS will have discretion on the timeline for further action.

Monitoring Requirements from the FWS

In order to monitor whether the amount or extent of incidental take anticipated from implementation of the project is approached or exceeded, the NPS shall adhere to the following reporting requirements. Should this anticipated amount or extent of incidental take be exceeded, the NPS must immediately reinitiate formal consultation as per 50 CFR 402.16.

1. For those components of the action that will result in habitat degradation or modification whereby incidental take in the form of harm is anticipated (i.e., fish removal by piscicides), the NPS will coordinate with the FWS before each annual piscicide fish eradication action is anticipated. Once a piscicide eradication is initiated, it may be followed through to completion, per the project description in the biological opinion, unless the take limit is exceeded during that action, indicating the need for immediate coordination with the FWS, and reinitiation. Updates shall also include any information about changes in project implementation that result in habitat disturbance not described in the Project Description and not analyzed in the Biological Opinion.

2. For those components of the action that result in direct encounters between listed species and project workers and their equipment, whereby take in the form of harassment, harm, injury, or death occurs that has not been analyzed in the Biological Opinion, the NPS shall immediately contact the Chief Endangered Species Forest Division, at the FWS's Sacramento Fish and Wildlife Office at (916) 414-6600 and via email to report the encounter. If encounter occurs after normal working hours, the NPS shall contact the FWS at the earliest possible opportunity the next working day.

3. The NPS will provide the FWS an annual report of incidental take associated with project activities covered by the biological opinion, which shall include: summary of project activities, total numbers of animals captured/swabbed/tagged/sampled, and the total numbers of individuals accidentally killed or injured. The annual report is due by February 28 of the succeeding calendar year for which the prior field season's activity is being reported.

4. The NPS will provide either: 1) interim documents every five (5) calendar years from the date this project is approved that will include: (a) summary discussions of significant research results; (b) maps and descriptions of completed and ongoing actions; (c) results of restoration efforts, including estimates of population sizes, if appropriate; (d) other pertinent observations regarding the status or ecology of the species; *or* 2) regularly disseminate the required information as part of (ongoing) annual Conservation Strategy meeting updates with the FWS and other agencies per the adaptive management process established in that document.

5. Should incidental take averages indicate higher than anticipated levels of incidental take trending above the authorized ten year incidental take estimates, the NPS will coordinate during the off season with the FWS to evaluate trends, adjust activities, or reinitiate consultation to ensure compliance under the Act.

6. The NPS will provide, no later than ten (10) calendar years following the first complete year of implementation of project activities, information to the FWS indicating project performance, including beneficial impacts in terms of areas of habitat restored, and any population level benefits observed, trends and study findings from monitoring and research, in order to evaluate the beneficial effects to frog populations from overall project activities in the context of incidental take. This project summary report will also include: (a) summary discussions of significant research results; (b) maps and descriptions of completed and ongoing actions; (c) results of restoration efforts, including estimates of population sizes, if appropriate; and (d) other pertinent observations regarding the status or ecology of the species. Presuming SEKI begins this project his season, the calendar date of the first interim project report will be February 28, 2026.

7. The FWS must be notified as soon as possible if large numbers of the northern DPS of the mountain yellow-legged frog, and/ or Sierra Nevada yellow-legged frog are found injured, sick or dead (e.g., due to illness, chemicals, or other factors), foul play is suspected, or unauthorized take of any listed species is observed or suspected. For such incidents, notification should be made by a NPS biologist, NPS law enforcement ranger, or other qualified NPS personnel. We recognize that the activities in this project will occur in the back country a substantial distance from roads, telephones, and cellphone FWS for long periods of time, so the notification should be made as soon as practicable. The report of the incident should include the date(s), location(s), habitat description, photographs, maps, preserved specimens (if possible), and any other pertinent information. The FWS contact is the Chief of the Endangered Species Division (Forest) at the Sacramento Fish and Wildlife Office at (916) 414-6621.

Deviations from these terms and conditions may be authorized in writing by the FWS as an appendage to the biological opinion.

The reasonable and prudent measure, with its implementing terms and conditions, is designed to minimize the impact of incidental take that might otherwise result from the proposed action. If, during the course of the action, this level of incidental take described for each species in the Amount or Extent of Take section is exceeded, such incidental take represents new information requiring reinitiation of consultation and review of the reasonable and prudent measures provided. The NPS must provide an explanation of the causes of the taking as soon as possible and review with the FWS the need for possible modification of the reasonable and prudent measure.

Conservation Recommendations from the FWS

Section 7(a)(1) of the Act directs Federal agencies to utilize their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened species.

Conservation recommendations are discretionary agency activities that can be implemented to further the purposes of the Act, such as preservation of endangered species habitat, implementation of recovery actions, or development of information and databases.

The FWS has the following recommendations:

1. The NPS should continue to assist the FWS in implementing the Conservation Strategy and, where applicable, recovery plans for the Northern Distinct Population Segment of the mountain yellow-legged frog, Sierra Nevada yellow-legged frog, Yosemite toad, Little Kern golden trout, and the Sierra Nevada bighorn sheep.

For the FWS to be kept informed of actions minimizing or avoiding adverse effects or benefiting listed species or their habitats, we request notification of the implementation of any of the conservation recommendations.

ALTERNATIVES CONSIDERED BUT DISMISSED FROM DETAILED ANALYSIS

Fish Eradication Using Biological Treatments
An alternative to eradicate nonnative fish using tiger muskies (*Esox masquinongy*) 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) It would not meet the plan's objectives of restoring native species diversity and ecological function of selected high elevation aquatic systems and the natural quality of wilderness, and it would be inconsistent with NPS *Management Policies 2006*.

The use of tiger trout (*Salmo trutta* X *Salvelinus fontinalis*), 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.

Frog Restoration Using <u>Only</u> Captive Rearing and Reintroduction
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. However, this program would not be successful if nonnative fish are not removed 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. Studies have shown that nonnative trout prey on MYLFs (Vredenburg 2004) and suppress MYLF populations (Knapp et al. 2007). Reintroductions are also challenging, even in fish-free waterbodies, and most reintroductions have been unsuccessful in the past.

Out of approximately nine recent MYLF reintroductions in SEKI and YOSE (NPS unpublished data) in fish-free waterbodies, three have begun to establish a breeding population (1 in SEKI, 2 in YOSE). It will take several years to determine if these populations persist or die out. The causes for the limited success of some MYLF reintroductions are not currently known. However, reintroductions have worked in many locations (e.g., Chandler et al. 2015), and may prove to be a vital conservation tool. More research on reintroductions is needed, and studies are currently underway to learn how to conduct reintroductions more successfully. Frog restoration using reintroductions alone was rejected from further consideration because it would not address the presence of self-sustaining popluations of nonnative fish and therefore would not meet the plan's objectives of restoring native species diversity and ecological function of selected high elevation aquatic systems and the natural quality of wilderness.

Fish Eradication Using Only Angling, Covering Redds, or Deploying Gill Nets
An alternative to eradicate nonnative fish using only angling, covering redds or deploying gill nets was considered. Eradicating fish by angling alone has not been demonstrated and thus 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 waterbodies are being proposed for nonnative fish eradication, and thus site restrictions would need to be developed to ensure proposed waterbodies were eradicated but other fish populations were not impacted. The 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 waterbodies, minimizing habitat damage, and protecting health and safety render this alternative infeasible from a management perspective. Finally, very few of the waterbodies 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.

It is possible to eradicate fish from certain waterbodies 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 waterbodies with attached streams that would prevent successful eradication using only gill nets (i.e., without the use of electrofishers). Gill nets do not work well in streams since they rapidly collect floating debris or snag on submerged rocks or branches. It is technically infeasible 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 waterbodies feasible for this option are too scarce and isolated to facilitate effective restoration at the landscape scale.

Covering or destroying redds is even more problematic than deploying only gill nets 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 the redds even more difficult to eliminate. If any redds are missed, the nonnative fish population, would likely persist.

All of the components considered in this alternative are important fish eradication tools used in combination with other actions described in alternatives B and C above, but they are inadequate for eradicating fish from proposed waterbodies either individually or used together. These methods, used on their own, would therefore not meet the plan's objectives of restoring native species diversity and ecological function of selected high elevation aquatic systems and the natural quality of wilderness. For these reasons, using these alternatives as the sole tools to eradicate fish populations was dismissed from further consideration.

Fish Eradication by Temporarily Drying Stream Segments or Small Waterbodies
Theoretically, this method would be an effective way to eradicate fish from smaller poritons of habitat and destroy any redds. However, drying of streams would only have the potential to eradicate fish from the affected stream habitats, and it would allow fish to remain in adjacent lakes. 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. Partial drying of very small waterbodies may facilitate fish eradication using gill nets, but it is unlikely to eradicate fish by itself. Drying of anything larger than small waterbodies is not feasible, and all of the fish eradication basins in consideration include larger waterbodies. In addition, a break in the piping would result in huge quantities of water would flowing over and eroding upland areas. This technique would also require potentially large temporary structures built in streams to divert the water and numerous equipment and personnel to move the pipe or conduit. Additionally, this method would unnecessarily eliminate (at least temporarily) fauna that are resistant to rotenone. Therefore, it has been dismissed from further consideration.

Fish Eradication Using the Piscicide Antimycin A
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. NPS management decisions attempt to adhere to state regulations when a feasible option (rotenone) exists. In addition, antimycin A currently is not being manufactured and thus is not available for purchase. 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.

Dispose of Fish Carcasses by burial
In the Restoration Plan/DEIS, the NPS considered disposing of fish carcasses by burial. This would result in the burial of potentially thousands of dead fish on land. This would be very difficult or impossible to achieve at high elevations, because (depending on the location) the amount of soil is limited, or soils are shallow or not present. Plus there were concerns with digging into and damaging unknown cultural sites which are scattered throughout the wilderness. Burying fish would also likely act as a significant attractant for scavengers. As most lake systems in the high Sierra are oligotrophic (nutrient lacking), allowing nutrients present in fish populations to be released directly to the aquatic ecosystem through decomposition is an important step for retaining limited nutrients and would be a long-term benefit to the restoration areas. Therefore burying the fish carcasses was ruled out as an option.

Complete Eradication of Nonnative Fish from All High Elevation Waterbodies
Complete eradication of nonnative fish populations from all high elevation waterbodies in SEKI is neither practical nor feasible to be considered in this Restoration Plan/FEIS. At this time it is known that nonnative fish are present in approximately 550 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 waterbodies. 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 waterbodies would eliminate all high elevation angling opportunities in SEKI, which is not the intention of this restoration plan. Therefore, this alternative has been dismissed from further consideration.

Treating MYLF for Amphibian Chytrid Fungus without Fish Removal
The FWS, NPS, USFS, and the CDFW are currently collaborating on the development of a conservation strategy for the Sierra Nevada yellow-legged frog (*R. sierrae*) and the northern distinct population segment of the 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 drafted that eradicating introduced fish and developing methods for successful translocations are the primary tools available for recovering the species. To survive, MYLFs must be protected in fishless habitats with long-term viability (i.e., interconnected habitats, including larger, deeper waterbodies that are necessary for successful overwintering and more resistant to climate change). While treatment for amphibian chytrid fungus is being explored, the methods and techniques have only begun to be field tested, and there is no evidence that the methods would be successful in restoring frog populations in the long-term without accompanying actions, including habitat restoration and translocations/reintroductions. Moreover, this alternative would not result in the removal of nonnative fish from targeted areas and therefore would not meet the plan's objectives of restoring native species diversity and ecological function of selected high elevation aquatic systems and the natural quality of wilderness.

Addressing other Known Stressors to MYLF and their habitat
Stop stock use in MYLF habitat: Riding stock and packstock use (including horses, mules, burros, and llamas) is permitted in SEKI wilderness. An extensive amount of long-term and ongoing monitoring data has been collected for MYLF populations in SEKI and YOSE, which has made it possible to quantify impacts from stock use. The vast majority of populations in SEKI and YOSE have received no to negligible impacts from stock use. In populations where impacts were detected (e.g. Sixty Lake Basin in SEKI), stock use is prohibited. In populations where impacts had reasonable potential to occur (e.g. upper LeConte Canyon in SEKI and Kerrick Meadow in YOSE), stock use is regulated to prevent such impacts. In addition, stock 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 and/or to protect sensitive habitat. Numerous studies have 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, FWS 2014A) and amphibian chytrid fungus (Rachowicz et al. 2006, Vredenburg et al. 2010A, FWS 2014A). Without removing nonnative fish from MYLF habitat, and implementing the restoration MYLF program, solely closing areas to stock use would not result in the restoration of MYLF or high elevation aquatic ecosystems.

Halt recreational activities in MYLF habitat: Reducing recreational activities in MYLF habitat would not meet the plan's objectives of restoring native species diversity or MYLF populations. As discussed above, nonnative trout and disease pose the highest risk to the conservation of the MYLF in SEKI. Second, recreational use, such as hiking and backpacking, is a negligible risk factor for MYLF conservation (FWS 2014A). While recreational activities occur 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 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 R., 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 activity in SEKI thus there would be no effect from this action.

Using Drought Conditions to Facilitate the Exclusive Use of Physical Fish Removal Methods
A comment was received during public review of the Restoration Plan/DEIS suggesting that SEKI use the 2012-2015 drought conditions to facilitate the exclusive use of physical fish removal methods. Episodic events such as droughts or low water years could potentially, temporarily, make physical methods somewhat more feasible for fish eradication. However, predicting, planning, and relying on such events is not a viable alternative for completing fish eradications and recovering MYLFs in SEKI. It is not feasible or prudent to design a long-term restoration plan that is dependent on a particular weather pattern to be successful. Based on previous successful physical restoration work in SEKI, physical methods take between three and 10 years, depending on the site. In order for this method to be successful, SEKI would have to (1) wait for at least three years of drought and hope that aquatic habitats would shrink enough to allow for eradication using physical methods; and (2) be ready with a crew to start that site in the first year of the drought. It is not feasible from a management perspective to schedule crews in this way because once restoration at a site begins, it needs to be consistently worked until eradication is achieved, and before moving to a new site. In addition, even if crews were available to start a new site in a drought year, there is no way to predict that the subsequent years would also bring the drought conditions needed for eradication using physical methods. The current 2015-2016 winter was wetter than the recent drought years - near the long-term average for precipitation in the southern Sierra Nevada. This demonstrates how highly variable weather cannot be relied upon to underpin a particular implementation strategy. Using drought conditions to facilitate the exclusive use of physical fish removal methods, therefore, is not a feasible alternative.

ENVIRONMENTALLY PREFERRED ALTERNATIVE

The CEQ defines the environmentally preferred alternative as "the alternative that will promote the national environmental policy as expressed in NEPA § 101. Section 101 states that it is the continuing responsibility of the Federal Government to:

1. Fulfill the responsibilities of each generation as trustee of the environment for succeeding generations;
2. Assure for all Americans safe, healthful, productive, and aesthetically and culturally pleasing surroundings;
3. Attain the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable and unintended consequences;
4. Preserve important historic, cultural, and natural aspects of our national heritage, and maintain, wherever possible, an environment which supports diversity and variety of individual choice;
5. Achieve a balance between population and resource use which will permit high standards of living and a wide sharing of life's amenities; and
6. Enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources.

The identification of the environmentally preferred alternative was based on analyses that balance factors such as number of sites to be treated, physical impacts on the environment, mitigation measures to minimize impacts, achievement of short- and long-term goals for restoration of high elevation ecosystems, and other factors, including the statutory mission of the NPS and the purposes for the project. For a comparison of the alternatives and the potential environmental effects under each alternative, see "Table 16. Alternatives Comparison" and "Table 17. Impact Summary Table." A full discussion of impacts is presented in "Chapter 4 - Environmental Consequences."

Alternative A, No Action maintains the *status quo*. This alternative limits restoration of native species in high elevation aquatic ecosystems to work initiated in 2001. It does not build on success of the 2001 work which demonstrated that nonnative fish eradication is feasible and beneficial to MYLFs, other native species and ecosystem function within a relatively short time (3 to 10 years). It does not initiate any new restoration efforts to restore and conserve native species in high elevation aquatic ecosystems. It partially supports the short-term goals for restoration of native species diversity and ecological function to SEKI's high elevation aquatic ecosystems, but the long-term goals would not be met. It does not protect or restore to the fullest measure available the wilderness resources, values, and diversity of recreational experiences. Alternative A would partially promote CEQ criteria 2 and 3 in that there would be no short-term resource degradation or risk to project personnel health and safety from the use of piscicides. However, the no action alternative would not arrest further degradation of MYLF populations in the parks, even in the short term. Over the long term, the failure to expand restoration actions to additional aquatic systems would result in a continued degraded state in these systems and the undesireable consequence of further depletions in MYLF populations. The no action alternative would not further CEQ criteria 1, 4, and 5 because actions to support the conservation of native species at risk of extirpation in the parks would not be sought, nor would the alternative allow for the restoration of additional high elevation native ecosystems. The no action alternative would not result in a better balance between those high elevation ecosystems that are heavily altered by nonnative fish and those that are not.

Alternative B, Prescription Treatment (Physical and Piscicide) Preceding Restoration is the NPS Environmentally Preferred Alternative because it would promote CEQ criteria 1, 4, and 5 because it would reverse the decline of native species in the parks and restore native ecosystems. This alternative proposes eradication of nonnative fish through the use of physical and piscicide treatment methods to optimize the number and size of restoration areas. Both methods target nonnative fish and could result in short-term adverse effects on native species. However in the long term, native species would be restored to high elevation aquatic ecosystems ensuring the preservation of natural aspects of our national heritage. While there would be short term effects to non-target species from the use of piscicides, these products degrade quickly and do not result in long term environmental effects. Angling opportunities would remain plentiful. In the short term, alternative B would not promote CEQ criteria 2, and 3 because it would result in a short-term degradation of natural resources and it would expose parks staff to piscicides. On the other hand, the restoration of MYLF populations and the removal of nonnative fish from additional areas would substantially promote criteria 2 and 4 over the long term. Alternative B would also promote the attainment of a wide range of beneficial uses over the long term by restoring MYLF populations and native ecosystems and minimizing the undesireable consequences of further reductions in these imperiled speices.

Alternative C, Physical Treatment Preceding Restoration proposes eradication of nonnative fish using physical treatment methods only. The number of restoration sites treated under this alternative would be less than two thirds (61%) of the restoration sites treated under alternatives B or D. The reduced restoration area does not fully promote the CEQ criteria. This alternative would be limited in its ability preserve and restore MYLF populations and native ecosystems because it would not use piscicide to remove nonnative fish from waterbodies. This alternative would partially promote criteria 2 and 3 in that there would be no short-term resource degradation or risk to project personnel health and safety from the use of piscicides. It would not fully promote CEQ criteria 1, 4, and 5 because the park would not implement all possible measures to conserve native species at risk of extirpation in the parks and native ecosystems, thus it would not promote the attainment of a wide range of beneficial uses in the long term.

Alternative D, Piscicide Treatment Preceding Restoration proposes eradication of nonnative fish using piscicide methods only. Piscicide treatment has more short-term effects on native species than physical treatment and thus would increase the need for more extensive restoration efforts after treatment. This alternative would promote CEQ criteria 1, 4, and 5 because it would reverse the decline of native species in the park and restore native ecosystems. It would not fully promote CEQ criteria 2 and 3 because it would result in a short-term degradation of natural resources and it would expose parks staff to piscicides. However, it would partially promote CEQ criteria 2 in that it would result in the restoration of MYLF populations and native ecosystems.

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Table 16. Alternatives Comparison

Project Objectives	Alternative A: No Action	Alternative B: Prescription Treatment (Physical and Piscicide) Preceding Restoration (Preferred Alternative)	Alternative C: Physical Treatment Preceding Restoration	Alternative D: Piscicide Treatment Preceding Restoration
Summary of Alternatives	This alternative limits nonnative fish eradications to 25 previously approved waterbodies, including two waterbodies for experimental restoration by researchers from 1997-1999, and 23 waterbodies for preliminary restoration by SEKI from 2001-2017. No new waterbodies for nonnative fish eradication are proposed.	Nonnative fish would be eradicated from of 85 waterbodies and 31 mi (50 km) of stream in 21 basins, including 52 waterbodies and 15 mi (25 km) of stream using physical treatment methods in 17 basins; and 33 waterbodies and 16 mi (25 km) of streams using piscicide treatment in 9 basins. MYLFs and other native species would be restored to these 85 waterbodies using natural recolonization where adjacent source populations exist, and reintroductions where adjacent source populations do not exist.	Nonnative fish would be eradicated from 52 waterbodies and 15 mi (25 km) of stream in 17 basins using physical treatment methods. Blasting is considered in up to five locations to create vertical fish barriers in streams. MYLFs and other native species would be restored to these 52 waterbodies using natural recolonization where adjacent source populations exist, and reintroductions where adjacent source populations do not exist.	Nonnative fish would be eradicated from 85 waterbodies and 31 mi (50 km) of stream in 21 basins using piscicide treatment only. MYLFs and other native species would be restored to these 85 waterbodies using natural recolonization where adjacent source populations exist, and reintroductions where adjacent source populations do not exist.
Objective A: Restore and conserve the natural abundances, distributions and functions of native species, populations, and communities within selected high elevation aquatic ecosystems, by: • implementing management actions to create more favorable conditions for these populations to persist and be more resilient to human-induced changes to environmental conditions; and • restoring habitat to its historically fishless condition at the parks scale, including the eradication of fish from up to 85 (15%) of 550 nonnative fish-containing lakes, ponds, and marshes, approximately 31 mi of streams, and connected fish-containing habitat as necessary.	*Does not meet objective:* No new waterbodies would be restored to their historically fishless condition, and thus 0% of 550 fish-containing lakes and ponds that are current candidates for eradication would continue to be impacted by self-sustaining nonnative trout populations.	*Fully meets objective:* A total of 85 new waterbodies would be restored to their historically fishless condition, and thus 15% of 550 fish-containing lakes and ponds that are current candidates for eradication would be restored, while 85% (465) would continue to be impacted by self-sustaining nonnative trout populations. A total of 21 basins would be restored, with new waterbodies ranging from approximately 6,000 to 12,000 ft (1,800 to 3,700 m) in elevation, and all of the parks' five major drainages would contain more than one restoration basin.	*Partially meets objective:* A total of 52 new waterbodies would be restored to their historically fishless condition, and thus 9% of 550 fish-containing lakes and ponds that are current candidates for eradication would be restored, while 91% (498) would continue to be impacted by self-sustaining nonnative trout populations. A total of 17 basins would be restored, with new waterbodies ranging from approximately 10,000 to 12,000 ft (3,000 to 3,700 m) in elevation, and three of the parks' five major drainages would contain more than one restoration basin.	*Fully meets objective:* Same as alternative B.

Project Objectives	Alternative A: No Action	Alternative B: Prescription Treatment (Physical and Piscicide) Preceding Restoration (Preferred Alternative)	Alternative C: Physical Treatment Preceding Restoration	Alternative D: Piscicide Treatment Preceding Restoration
Objective B: Develop a long-term conservation strategy for both species of MYLFs (*Rana muscosa* and *Rana sierrae)* to ensure the self-sustaining, long-term viability and evolution of MYLF populations in perpetuity within portions of their present and historic geographic range within the parks, and to maintain the genetic and ecological diversity of these species. Specific objectives related to this strategy include: • reverse widespread loss of the ecological function formerly provided by MYLFs and maintain the viability of existing MYLF populations throughout the range of both species within the parks; • restore selected habitat and expand existing MYLF populations; • re-establish MYLFs in selected basins where populations were historically present but are now absent; and • collaborate with partner agencies and organizations to exchange information, enhance use of available resources, and strategically restore and conserve MYLFs in the Sierra Nevada.	*Does not meet objective:* A MYLF conservation strategy would be developed in collaboration with partner agencies and organizations, but no new MYLF habitat is restored, no existing MYLF populations are allowed to expand into restored habitat, and no MYLF populations are re-established in basins where they have gone absent. Therefore, widespread loss of the ecological function provided by MYLF is not prevented, and the viability of existing MYLF populations is compromised.	*Fully meets objective:* A MYLF conservation strategy would be developed in collaboration with partner agencies and organizations. To the maximum extent feasible during the life of this plan, new MYLF habitat is restored, existing MYLF populations are allowed to expand into restored habitat, and MYLF populations are re-established in basins where they have gone absent. Therefore, widespread loss of the ecological function provided by MYLFs is prevented, and the viability of existing MYLF populations is maintained, as much as is possible during the life of this plan.	*Partially meets objective:* A MYLF conservation strategy would be developed in collaboration with partner agencies and organizations. To a more limited extent, new MYLF habitat is restored, existing MYLF populations are allowed to expand into restored habitat, and MYLF populations are re-established in basins where they have gone absent. Therefore, widespread loss of the ecological function provided by MYLF is prevented, and the viability of existing MYLF populations is maintained, but to a lesser extent than is feasible during the life of this plan.	*Fully meets objective:* Same as alternative B.
Objective C: Identify presently incomplete information that is needed for effective conservation and management of aquatic ecosystems in the face of unprecedented rates of human- induced change.	*Fully meets objective:* SEKI would collaborate with partner agencies and organizations to facilitate high-priority research of aquatic ecosystems.	*Fully meets objective:* Same as alternative A.	*Fully meets objective:* Same as alternative A.	*Fully meets objective:* Same as alternative A.

Project Objectives	Alternative A: No Action	Alternative B: Prescription Treatment (Physical and Piscicide) Preceding Restoration (Preferred Alternative)	Alternative C: Physical Treatment Preceding Restoration	Alternative D: Piscicide Treatment Preceding Restoration
Objective D: Use results from restoration efforts and new knowledge from research studies to refine program methodologies over time and mitigate impacts that have the potential to occur during restoration.	*Partially meets objective:* New restoration efforts would not be conducted. Results from preliminary restoration, plus new data from scientific studies, would allow for minimal refinement of restoration methodologies. This alternative would have the least educational benefit to SEKI and other organizations conducting restoration.	*Fully meets objective:* New restoration efforts would be conducted, using two fish eradication methods, to the maximum extent feasible during the life of this plan. These results, plus new data from scientific studies, would allow for a robust refinement of restoration methodologies. This alternative would have the greatest educational benefit to SEKI and other organizations conducting restoration.	*Partially meets objective:* New restoration efforts would be conducted, using one fish eradication method, to a more limited extent compared to alternatives B and D. These results, plus new data from scientific studies, would allow for a moderate refinement of restoration methodologies. This alternative would have a moderate educational benefit to SEKI and other organizations conducting restoration.	*Partially meets objective:* New restoration efforts would be conducted, using one fish eradication method, to the maximum extent feasible during the life of this plan. These results, plus new data from scientific studies, would allow for a moderate refinement of restoration methodologies. This alternative would have the same educational benefit to SEKI and other organizations conducting restoration as alternative C.
Objective E: Restore and protect natural processes in wilderness, using an appropriate range of management actions derived from thorough analyses of potential effects to wilderness character and resources.	*Does not meet objective:* Natural qualities in wilderness would not be restored and would continue to be impacted by self-sustaining nonnative trout populations in 550 waterbodies plus connecting streams.	*Partially meets objective:* Natural qualities in wilderness would be restored to the maximum extent feasible during the life of this plan, by eliminating impacts being caused by self-sustaining nonnative trout populations in 85 waterbodies and 31 mi (50 km) of streams, plus connected fish-containing habitat as necessary. However, there would still be self-sustaining nonnative trout populations present in approximately 465 waterbodies plus connecting streams.	*Partially meets objective:* Natural qualities in wilderness would be restored to a more limited extent compared to alternatives B and D, by eliminating impacts being caused by self-sustaining nonnative trout populations in 52 waterbodies and 15 mi (25 km) of streams, plus connected fish-containing habitat as necessary. However, there would still be self-sustaining nonnative trout populations present in approximately 498 waterbodies plus connecting streams.	*Partially meets objective:* Same as alternative B.
Objective F: Provide an appropriate range of visitor experiences and recreational opportunities at wilderness lakes and streams concurrent with minimizing the degradations that have occurred to the biological integrity of high elevation aquatic ecosystems.	*Does not meet objective:* A range of visitor experiences and recreational opportunities at wilderness lakes and streams would be provided, including differing experiences at fishless and fish-containing lakes; but existing impacts to the biological integrity of high elevation aquatic ecosystems would not be minimized, as self-sustaining nonnative trout populations would continue to impact 550 waterbodies plus connecting streams.	*Fully meets objective:* A range of visitor experiences and recreational opportunities at wilderness lakes and streams would be provided, including differing experiences at multiple fishless and fish-containing lakes. Existing impacts to the biological integrity of high elevation aquatic ecosystems would be minimized to the maximum extent feasible during the life of this plan, as self-sustaining nonnative trout populations would be eradicated from 85 waterbodies and 31 mi (50 km) of streams, plus connected fish-containing habitat as necessary. The techniques used would have more short-term impacts than alternative C, but fewer short-term impacts than alternative D.	*Partially meets objective:* A range of visitor experiences and recreational opportunities at wilderness lakes and streams would be provided, including differing experiences at multiple fishless and fish-containing lakes. Existing impacts to the biological integrity of high elevation aquatic ecosystems would be minimized to a more limited extent compared to alternatives B and D, as self-sustaining nonnative trout populations would be eradicated from 52 waterbodies and 15 mi (25 km) of streams, plus connected fish-containing habitat as necessary. The techniques used would have the least short-term impacts of any action alternative.	*Partially meets objective:* A range of visitor experiences and recreational opportunities at wilderness lakes and streams would be provided, including differing experiences at multiple fishless and fish-containing lakes. Existing impacts to the biological integrity of high elevation aquatic ecosystems would be minimized to the maximum extent feasible during the life of this plan, as self-sustaining nonnative trout populations would be eradicated from 85 waterbodies and 31 mi (50 km) of streams, plus connected fish-containing habitat as necessary. The techniques used would have the most short-term impacts of any action alternative.

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Table 17 is provided to show a summary of the differences between the alternatives. For detailed information on the impacts from each alternative and a description of the Impacts from Elements Common to All Action Alternatives, see chapter 4.

Table 17. Impact Summary Table

Impact Topic	Actions Common to All Alternatives	Summary of Impacts Alternative A: No Action	Summary of Impacts Alternative B: Prescription Treatment (Physical and Piscicide) Preceding Restoration (Preferred Alternative)	Summary of Impacts Alternative C: Physical Treatment Preceding Restoration	Summary of Impacts Alternative D: Piscicide Treatment Preceding Restoration
Special-Status Species *Mountain Yellow-legged Frogs (MYLF)* *Yosemite Toad* *Little Kern Golden Trout* *Sierra Nevada Bighorn Sheep*	• The establishment and use of crew camps would have no effect on special status species. • The use of helicopter and/or stock to support crew camps would have no effect on MYLF, Yosemite toad, and Little Kern golden trout. The use of helicopters may affect, but is not likely to adversely affect Sierra Nevada bighorn sheep due to potential for flight responses. The use of stock would have no effect on bighorn sheep. • The restoration of MYLF (1) would have no effect on Yosemite toad and Little Kern golden trout; (2) may affect, but is not likely to adversely affect bighorn sheep due to potential for flight responses due to helicopter use for restoration activities; and 3) would have short-term adverse effects and long-term beneficial effects on MYLF. • Relocation of garter snakes from MYLF reintroduction and translocation sites would have short-term beneficial effects on MYLFs by removing immediate threats from predation and long-term beneficial effects on MYLF as populations become established. Garter snakes would not be relocated to areas containing populations of MYLFs or Yosemite toads. Therefore, moving garter snakes would have no effect on Sierra Nevada bighorn sheep, Little Kern golden trout, or Yosemite toads. • Monitoring, research, and scientific study would have no effect on Yosemite toad, Little Kern golden trout, and Sierra Nevada bighorn sheep. Handling some individual MYLF may adversely affect individual frogs, but there would be long-term beneficial effects from increased resistance to chytrid fungus. • Fish disposal would have no adverse effects on special status species and short-term beneficial effects on MYLF and Yosemite toads from nutrient pulses related to fish decomposition.	MYLF: • *may affect, likely to adversely affect* from gill netting and electrofishing in 25 waterbodies and 3.7 mi (6.0 km) of streams in seven basins, due to the potential for disturbance, injury or mortality to individuals. • *long-term beneficial effects* in 25 treated waterbodies and 3.7 mi (6.0 km) of streams contained in seven basins, due to expected increases in existing populations to a larger (less-vulnerable) size in response to nonnative trout removal, and the reestablishments of populations in restored habitat. • *No effect* on Yosemite toad, Little Kern golden trout, and Sierra Nevada bighorn sheep.	MYLF: • *may affect, likely to adversely affect* from gill netting and electrofishing in an additional 52 waterbodies and 15 mi (25 km) of streams in 17 basins, and from piscicide use in an additional 33 waterbodies and 16 mi (25 km) of streams in 9 basins, due to the potential for disturbance, injury or mortality to individuals. • *long-term beneficial effects* in an additional 85 treated waterbodies and 31 mi (50 km) of streams contained in 21 basins, due to expected increases in existing populations to a larger (less-vulnerable) size in response to nonnative trout removal, and the reestablishments of populations in restored habitat. • Yosemite toad: *no effect* in 19 of the 21 treated basins; *may affect, likely to adversely affect* in Upper Evolution and McGee. • Little Kern golden trout: *no effect* in 20 of the 21 treated basins; *may affect, likely to adversely affect* in Crytes due to the eradication of this population of Little Kern golden trout. • Sierra Nevada bighorn sheep: *no effect* in 19 of the 21 treated basins; *may affect, not likely to adversely affect* in Sixty Lake and Laurel.	MYLF: • *may affect, likely to adversely affect* from gill netting and electrofishing in an additional 52 waterbodies and 15 mi (25 km) of streams in 17 basins, and potentially from blasting in up to five locations, due to the potential for disturbance, injury or mortality to individuals. • *long-term beneficial effects* in an additional 52 treated waterbodies and 15 mi (25 km) of streams contained in 17 basins, due to expected increases in existing populations to a larger (less-vulnerable) size in response to nonnative trout removal, and the reestablishments of populations in restored habitat. • Yosemite toad: *no effect* in 15 of the 17 treated basins; *may affect, likely to adversely affect* in Upper Evolution and McGee. • Little Kern golden trout: *no effect* in 16 of the 17 treated basins; *may affect, likely to adversely affect* in Crytes due to the eradication of this population of Little Kern golden trout. • Sierra Nevada bighorn sheep: *no effect*	MYLF: • *may affect, likely to adversely affect* from piscicide use in an additional 85 waterbodies and 31 mi (50 km) of streams in 21 basins, due to the potential for disturbance, injury or mortality to individuals. • *long-term beneficial* effects in an additional 85 treated waterbodies and 31 mi (50 km) of streams contained in 21 basins, due to expected increases in existing populations to a larger (less-vulnerable) size in response to nonnative trout removal, and the reestablishments of populations in restored habitat. • Yosemite toad: *no effect* in 19 of the 21 treated basins; *may affect, likely to adversely affect* in Upper Evolution and McGee. • Little Kern golden trout: *no effect* in 20 of the 21 treated basins; *may affect, likely to adversely affect* in Crytes due to the eradication of this population of Little Kern golden trout. • Sierra Nevada bighorn sheep: *no effect* in 19 of the 21 treated basins; *may affect, not likely to adversely affect* in Sixty Lake and Laurel.
Wildlife *Vertebrates*	**Vertebrates** • The establishment and use of crew camps may cause short-term disturbance and flight response, resulting in short-term negligible adverse effects. • Helicopter and stock use would result in short-term disturbances and flights responses, resulting in short-term negligible adverse effects to some vertebrates, and no effect to	**Vertebrates** • Short-term moderate adverse effects on vertebrates from gill netting and electrofishing in 25 waterbodies and 3.7 mi (6.0 km) of streams contained in seven basins, due to the potential for disturbance, injury or mortality to individuals. • Long-term beneficial effects on vertebrates in 25 treated waterbodies and 3.7 mi (6.0 km) of	**Vertebrates** • Short-term moderate adverse effects on vertebrates from gill netting and electrofishing in an additional 52 waterbodies and 15 mi (25 km) of streams in 17 basins, and from piscicide use in an additional 33 waterbodies and 16 mi (25 km) of streams in 9 basins, due to the potential for disturbance, injury or mortality to individuals.	**Vertebrates** • Short-term moderate adverse effects on vertebrates from gill netting and electrofishing in an additional 52 waterbodies and 15 mi (25 km) of streams in 17 basins, and potentially from blasting in up to five locations, due to the potential for disturbance, injury or mortality to individuals. • Long-term beneficial effects on vertebrates in	**Vertebrates** • Short-term moderate adverse effects on vertebrates from piscicide use in an additional 85 waterbodies and 31 mi (50 km) of streams in 21 basins, due to the potential for disturbance, injury or mortality to individuals. • Long-term beneficial effects on vertebrates in an additional 85 treated waterbodies and 31

Impact Topic	Actions Common to All Alternatives	Summary of Impacts Alternative A: No Action	Summary of Impacts Alternative B: Prescription Treatment (Physical and Piscicide) Preceding Restoration (Preferred Alternative)	Summary of Impacts Alternative C: Physical Treatment Preceding Restoration	Summary of Impacts Alternative D: Piscicide Treatment Preceding Restoration
	others. • Fish disposal would result in both short and long-term negligible effects on vertebrates due to changes in nutrient and water chemistry, and short- and long-term beneficial effects from increased food sources during fish decomposition. • Restoration, research, and scientific studies would have short-term negligible adverse effects from disturbance on all vertebrates but garter snakes; short-term minor adverse effects on local garter snake populations from relocations (negligible impacts at park scale); and long-term beneficial effects on all vertebrates from restoration.	streams contained in seven basins, due to increased natural food sources in response to nonnative trout removal.	• Long-term beneficial effects on vertebrates in an additional 85 treated waterbodies and 31 mi (50 km) of streams contained in 21 basins, due to increased natural food sources in response to nonnative trout removal.	an additional 52 treated waterbodies and 15 mi (25 km) of streams contained in 17 basins, due to increased natural food sources in response to nonnative trout removal.	mi (50 km) of streams contained in 21 basins, due to increased natural food sources in response to nonnative trout removal.
Invertebrates	**Invertebrates** • The establishment and use of crew camps would result in negligible adverse effects on invertebrates associated with disturbance, flight response, and trampling. • Helicopter and stock use would result in no to negligible effects. • Fish disposal activities would result in negligible adverse effects due to disturbance, and beneficial effects due to increases in nutrients released via fish decomposition. • Restoration, research, and scientific studies would have short-term negligible adverse effects on invertebrates from disturbance, and long-term beneficial effects from ecosystem restoration.	**Invertebrates** • Short-term negligible to minor adverse effects on invertebrates from gill netting and electrofishing in 25 waterbodies and 3.7 mi (6.0 km) of streams in seven basins, due to the potential for disturbance, injury, or mortality to individuals. • Long-term beneficial effects on invertebrates in 25 treated waterbodies and 3.7 mi (6.0 km) of streams contained in seven basins, due to invertebrate populations increasing in abundance, distribution and diversity in response to nonnative trout removal.	**Invertebrates** • Short-term negligible to minor adverse effects on invertebrates from gill netting and electrofishing in an additional 85 waterbodies and 31 mi (50 km) of streams in 21 basins, due to the potential for disturbance, injury, or mortality to individuals. • Short-term major adverse effects from piscicide use in an additional 33 waterbodies and 16 mi (25 km) of streams contained in 9 basins, due to disturbance, injury or mortality to individuals and reduction in abundance and diversity of populations. • Long-term moderate adverse effects from piscicide use in an additional 33 waterbodies and 16 mi (25 km) of streams contained in 9 basins, due to the potential for prolonged reduction in abundance and diversity of populations. • Long-term beneficial effects on invertebrates in an additional 85 treated waterbodies and 31 mi (50 km) of streams contained in 21 basins, due to invertebrate populations increasing in abundance, distribution and diversity in response to nonnative trout removal.	**Invertebrates** • Short-term negligible to minor adverse effects on invertebrates from gill netting and electrofishing in an additional 52 waterbodies and 15 mi (25 km) of streams in 17 basins, and potentially from blasting in up to five locations, due to the potential for disturbance, injury, or mortality to individuals. • Long-term beneficial effects on invertebrates in an additional 52 treated waterbodies and 15 mi (25 km) of streams contained in 17 basins, due to invertebrate populations increasing in abundance, distribution and diversity in response to nonnative trout removal.	**Invertebrates** • Short-term major adverse effects on invertebrates from piscicide use in an additional 85 waterbodies and 31 mi (50 km) of streams in 21 basins due to disturbance, injury, or mortality to individuals and reduction in abundance and diversity of populations. • Long-term moderate adverse effects on invertebrates from piscicide use in an additional 85 waterbodies and 31 mi (50 km) of streams contained in 21 basins, due to the potential for prolonged reduction in abundance and diversity of populations. • Long-term beneficial effects on invertebrates in an additional 85 treated waterbodies and 31 mi (50 km) of streams contained in 21 basins, due to invertebrate populations increasing in abundance, distribution and diversity in response to nonnative trout removal.
Wild and Scenic Rivers	Crew camps, helicopter and stock use, and restoration, monitoring, research, and fish disposal would have no direct effects on wild and scenic rivers. In upper basin areas associated with wild and scenic rivers, there would be limited indirect effects on scenic values related to the presence of crews working and camping in project areas near tributaries to wild and scenic rivers. Recreational, fish, and wildlife values would be changed in the future as ecosystems are restored, primarily due to an increase in opportunities to view native wildlife. This would result in beneficial effects to	There would be long-term adverse effects on recreational opportunities related to decreased fishing opportunities in upper basin areas that drain into wild and scenic rivers, and long-term beneficial effects on native wildlife populations, but to a lesser degree than alternatives B, C, and D.	There would be long-term adverse effects on recreational opportunities related to decreased recreation (fishing) in upper basin areas associated with wild and scenic rivers, and long-term beneficial effects on native wildlife populations.	There would be long-term adverse effects on recreational opportunities related to decreased recreation (fishing) in upper basin areas associated with wild and scenic rivers, and long-term beneficial effects on native wildlife populations, but to a lesser degree than alternatives B and D.	Same as alternative B.

Impact Topic	Actions Common to All Alternatives	Summary of Impacts Alternative A: No Action	Summary of Impacts Alternative B: Prescription Treatment (Physical and Piscicide) Preceding Restoration (Preferred Alternative)	Summary of Impacts Alternative C: Physical Treatment Preceding Restoration	Summary of Impacts Alternative D: Piscicide Treatment Preceding Restoration
	associated wild and scenic rivers values.				
Water Quality	• Crew camps would have a negligible effect on water quality due to a slight potential for upland sediment, food, and personal care items to reach waterways. • The use of helicopters would have no effect on water quality. Stock use would result in a negligible to minor adverse effect on water quality. • The restoration, monitoring, and research program would result in short-term negligible to minor adverse effects on a localized scale during project work; the long-term effects would be beneficial as healthy functioning native ecosystems are restored. • Impacts of fish disposal on water quality would be short-term, negligible to moderate and adverse based on the type of operation (whether gill netting or piscicide use) and the timing (more fish are caught during the early stages of the treatment).	This alternative would have short-term negligible adverse impacts on water quality due to slight increases in turbidity during project work from walking in and adjacent to waterbodies.	Physical treatments would result in short-term negligible adverse effects on water quality due to slight increases in turbidity during project work from walking in and adjacent to waterbodies. Piscicide treatments, including increased turbidity during project work and the application of rotenone to treated areas would result in short-term negligible to minor adverse impacts on water quality.	Physical treatments would result in short-term negligible adverse effects on water quality due to slight increases in turbidity during project work from walking in and adjacent to waterbodies and from blasting.	Piscicide treatments, including increased turbidity during project work and the application of rotenone to treated areas would result in short-term negligible to minor adverse impacts on water quality.
Wilderness Character (untrammeled, natural, undeveloped, opportunities for solitude or primitive and unconfined recreation, other features of value).	**Untrammeled:** • Crew Camps – No effect. • Use of Helicopter and Stock – No effect. • Restoration, Monitoring, and Research – Restoration would result in trammeling actions periodically for the life of the project (20 to 35 years). Monitoring and research sometimes result in trammeling actions if there is intentional manipulation of the natural environment. • Fish Disposal - 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.	**Untrammeled:** There would continue to be trammeling actions at two basins until the current restoration project is completed in 2017. Trammeling actions include netting and electrofishing to remove nonnative fish from the lakes and streams within the project area.	**Untrammeled:** The project itself constitutes a long-term trammel as it would continue for the next 25 to 35 years. There would be site-specific trammeling associated with the removal of nonnative fish at up to six treatment sites per year, for several weeks each summer, over a one to seven year period, with some sites treated for up to 10 years. There would be additional trammeling associated with invertebrate sampling as part of pre- or post-treatment assessments at up to four sites per year, one to two weeks per site per summer, over a four year period. This alternative includes physical and piscicide treatments that involve trammeling actions at 85 waterbodies and 31 mi (50 km) of streams, plus connected fish-containing habitat (as necessary). This alternative results in more trammeling actions than alternative A and C, and the same as alternative D, but trammeling actions would occur over a longer time period under this alternative (up to 35 years vs. up to 20 years).	**Untrammeled:** The project itself constitutes a long-term trammel as it would continue for the next 25 to 35 years. There would be site-specific trammeling associated with the removal of nonnative fish at up to six treatment sites per year, for several weeks each summer, over a five to seven year period, with some sites treated for up to 10 years. This alternative includes physical treatment that involves trammeling actions at 52 waterbodies and 15 mi (25 km) of streams, plus connected fish-containing habitat (as necessary). Blasting rock to create vertical fish barriers at up to five locations is an intentional manipulation of the stream substrate, resulting in a long-term manipulation of the biophysical environment and a permanent modification/trammel of the stream. This alternative results in more trammeling actions than alternative A, and fewer trammeling actions than alternatives B and D, but includes a permanent trammeling action.	**Untrammeled:** The project itself constitutes a long-term trammel as it would continue for the next 15 to 20 years. There would be site-specific trammeling associated with the removal of nonnative fish at up to two treatment sites per year, two to four weeks per site per summer, over a one to two year period for most piscicide treatments, and potentially up to three years for one or more of the largest piscicide treatments. There would be slight site-specific trammeling associated with invertebrate sampling as part of pre- or post-treatment assessments at up to four sites per year, one to two weeks per site per summer, over a four year period. This alternative includes piscicide treatment that involves trammeling actions at 85 waterbodies and 31 mi (50 km) of streams, plus connected fish-containing habitat (as necessary). This alternative results in more trammeling actions in the short-term than all other alternatives and fewer trammeling actions in the long-term because treatment actions would be accomplished faster.

Impact Topic	Actions Common to All Alternatives	Summary of Impacts Alternative A: No Action	Summary of Impacts Alternative B: Prescription Treatment (Physical and Piscicide) Preceding Restoration (Preferred Alternative)	Summary of Impacts Alternative C: Physical Treatment Preceding Restoration	Summary of Impacts Alternative D: Piscicide Treatment Preceding Restoration
	Natural • Crew Camps - Small crews staying in one location for several weeks would 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. Areas have been shown to recover after project work thus there would be no long-term effect on the natural from crew camps. • Helicopters and Stock - Helicopters affect the natural quality of wilderness by causing disturbance and flight responses in wildlife causing short-term minor adverse effects. Stock use would result in short-term minor adverse effects from trampling and stock waste. • Restoration, Monitoring, and Research - Short-term minor to moderate adverse effects, but long-term beneficial effects on native ecosystems as species are prevented from going extinct, and ecosystem restoration is accomplished. • Fish Disposal – There would be a short-term effect as a result of adding nutrients to the system as fish biodegrade, and also by providing an unnatural food source to native wildlife.	**Natural:** Long-term beneficial effects from restoring the natural ecosystem and processes in 25 waterbodies.	**Natural:** Long-term beneficial effects from restoring the natural quality of wilderness in 15% of the approximately 550 waterbodies that are known to contain nonnative fish populations. Short-term moderate to major adverse effects from the use of piscicides. This alternative results in more restoration of the natural quality (more treatment sites) than alternatives A and B, and the same level of restoration as alternative D, but alternative D would be accomplished in a shorter time period.	**Natural:** Long-term beneficial effects from restoring the natural quality of wilderness in 9% of the approximately 550 waterbodies that are known to contain nonnative fish populations. However, most long reaches of streams, large lakes, and interconnected lake complexes would not be treated and the natural quality of wilderness would continue to be adversely affected. Long-term minor to moderate adverse effects to the natural quality of wilderness due to blasting in up to five locations. This alternative results in more restoration of the natural quality (more treatment sites) than alternative A, but less than alternatives B and D.	**Natural:** Long-term beneficial effects of restoring the natural quality of wilderness in 15% of the 550 waterbodies known to contain nonnative fish populations. Short-term moderate to major adverse effect on the natural quality of wilderness from the use of piscicides. This alternative results in the most short-term adverse effects on the natural quality from the exclusive use of piscicides, and would result in the restoration of the same number of sites as alternative B, but restoration of the natural quality at treatment sites would be accomplished in a shorter time period.
	Undeveloped • Crew Camps - Short- term minor to moderate adverse effects from the presence of crew camps and associated installations and transport of supplies. • Helicopter and Stock Use – Helicopter flights would result in a short-term minor to moderate adverse effect. Stock use would have no effect. • Restoration, Monitoring, and Research – These activities could include temporary installations, resulting in minor to moderate short- and long-term adverse effects on undeveloped. • Fish Disposal – There is no effect on undeveloped.	**Undeveloped:** The tools used to accomplish the restoration (the installation of nets, storage lockers, and the use of helicopters) create short- to long-term minor to moderate adverse effects on the undeveloped quality of wilderness.	**Undeveloped:** The installation of gill nets, the presence of crew camps and storage lockers, the use of small electric pumps and motors associated with piscicide use, and the use of helicopters create short-term adverse effects on the undeveloped quality of wilderness. There would be up to six crew camps in wilderness per year, generally occupying each site periodically through the summer season for approximately six years per lake or pond treatment site, and up to 10 years at treatment sites with long or complex streams. This alternative results in the greatest effect on the undeveloped quality as more tools are used at more locations.	**Undeveloped:** The installation of gill nets, the presence of crew camps and storage lockers, blasting of streams to create barriers, and the use of helicopters create short-term adverse effects on the undeveloped quality of wilderness. There would be up to five temporary crew camps in wilderness per year, generally occupying each site for several weeks each season for approximately six years per site for lakes and ponds, and up to 10 years for sites with long or complex streams. Blasting would create a long-term minor adverse effect on the undeveloped quality of wilderness in up to five locations because “the imprint of man’s work” (i.e. visible scarring) would remain. This alternative results in a greater effect on the undeveloped quality than alternative A and D, but fewer effects than alternative B, as fewer tools are used at fewer locations.	**Undeveloped:** The presence of crew camps and storage lockers, the use of small electric pumps and motors associated with piscicide use, and the use of helicopters create short-term adverse effects on the undeveloped quality of wilderness. There would be up to six temporary crew camps in wilderness per year, including up to two conducting piscicide treatment activities and up to four conducting pre- or post-treatment assessment activities. Treatment sites would be occupied for two to four weeks in the summer for up to one to two years per site for most piscicide treatments, and potentially up to three years for one or more of the largest piscicide treatments; assessment sites would be occupied for one to two weeks in the summer for up to four years per site. Short-term storage locker installations would be needed to secure piscicide in crew camps before use. Helicopter use would be similar to alternative B.

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					This alternative results in the least impact on the undeveloped quality as fewer mechanized/motorized tools are used, there are fewer installations, and there would be no long-term "imprint of man's work" since there is no blasting included.
	Opportunities for solitude or primitive and unconfined recreation: • Crew Camps- The presence of crew camps in several locations in the wilderness would reduce opportunities for solitude in the project areas. • Helicopter and Stock Use – Helicopters would reduce opportunities for solitude and unconfined recreation on a temporary basis. Stock use could reduce opportunities for solitude on a temporary basis. • Restoration, Monitoring, and Research - The presence of crews associated with these activities would result in negligible to minor adverse effects on solitude. There would be minor adverse effects on opportunities for primitive recreation as a result of the loss of angling opportunities at restoration sites and long-term beneficial effects from restoring opportunities to view native wildlife. • Fish Disposal – No effect.	**Opportunities for solitude or primitive and unconfined recreation:** Long-term minor adverse effects on opportunities for primitive recreation (e.g. angling) resulting from the eradication of nonnative trout from 25 of the parks' waterbodies. Negligible adverse effect on solitude from the presence of two to three person crews. Long-term beneficial effects from the restoration of healthy native ecosystems at treated sites, leading to enhanced opportunities for primitive recreation.	**Opportunities for solitude or primitive and unconfined recreation:** Negligible adverse effect on solitude from the presence of one to six crews comprising two to three persons for physical treatment methods, and eight to 15 people for most piscicide treatment methods, and potentially up to 16 to 25 people for one or more of the largest piscicide treatments. Long-term minor to moderate adverse effects on opportunities for primitive recreation (e.g. angling) resulting from reduced angling opportunities at 85 of the parks' waterbodies and 31 mi (50 km) of streams. Long-term beneficial effects from the restoration of healthy native ecosystems at treated sites, leading to enhanced opportunities for primitive recreation. Short-term adverse effects on unconfined recreation from area closures due to the application of piscicides. This alternative changes opportunities for solitude or primitive and unconfined recreation more than alternatives A and C, but less than alternative D. Angling opportunities would be reduced in the same locations as alternative D, but at a slower rate. Native wildlife viewing would be increased at the same locations as alternative D, but at a slower rate.	**Opportunities for solitude or primitive and unconfined recreation:** Negligible adverse effect on solitude from the presence of one to five crews comprising two to three persons. Long-term minor adverse effects on opportunities for primitive recreation (e.g. angling) resulting from the eradication of nonnative trout from 52 of the parks' waterbodies and 15 mi (25 km) of streams. Long-term beneficial effects from the restoration of healthy native ecosystems at treated sites, leading to enhanced opportunities for viewing native wildlife in wilderness. This alternative changes opportunities for solitude or primitive and unconfined recreation more than alternative A, and less than alternatives B and D. Angling opportunities would be reduced in fewer locations than alternatives B and D. Native wildlife viewing opportunities would be available at fewer locations than alternatives B and D.	**Opportunities for solitude or primitive and unconfined recreation:** Negligible to minor adverse effect on solitude from the presence of one to two crews comprising eight to 15 people for two to four weeks over a one to two year period for most piscicide treatment methods, and potentially up to 16 to 25 people for two to four weeks over a one to three year period for one or more of the largest piscicide treatments. Negligible adverse effect on solitude from the presence of one to four crews comprised of two to four people for one to two weeks during pre- or post-treatment assessment activities. Long-term minor to moderate adverse effects on opportunities for primitive recreation (e.g. angling) resulting from the eradication of nonnative trout from 85 of the parks' waterbodies and 31 mi (50 km) of streams. Short-term adverse effects from area closures due to the application of piscicides. Long-term beneficial effects from the restoration of healthy native ecosystems at treated sites, leading to improved opportunities for viewing native wildlife in wilderness This alternative changes opportunities for solitude or primitive and unconfined recreation the most, as crews would be larger and more areas would be closed to visitor use during treatment activities. Angling opportunities would be reduced in the same locations as alternative B, but would be reduced at a faster rate. Native wildlife viewing opportunities would be available at more locations in a shorter time period than alternatives A, B, and C.
Natural Soundscapes	• Crew Camps - The presence of these camps may adversely affect the visitor experience for those who hear noise generated from the camp areas, but this noise would primarily be crew members talking and would be short-term, temporary and localized, resulting in short- term negligible adverse impacts on natural soundscapes. • Helicopter and Stock Use - the use of helicopters results in short-term moderate	Sounds made by crews would have a short-term negligible adverse impact on natural soundscapes in a localized area. As each restoration site is completed, natural sounds would be restored as native species return to the sites. This would improve the natural soundscapes in the restoration areas. Under this limited restoration alternative, components of the natural soundscape over much of the high elevation landscape, including	Sounds made by crews would have a short-term negligible adverse impact on natural soundscapes in a localized area. As each restoration site is completed, natural sounds would be restored as native species return to the sites. This would improve the natural soundscapes in the restoration areas. The natural soundscape would be restored in more areas than alternatives A and C, and in the same number of areas as alternative D but at a	Sounds made by crews would have a short-term negligible adverse impact on natural soundscapes in a localized area. As each restoration site is completed, natural sounds would be restored as native species return to the sites. This would improve the natural soundscapes in the restoration areas. Noise from blasting to create vertical fish barriers in up to five locations would result in a short-term minor to moderate adverse effect on	Sounds made by crews would have a short-term negligible adverse impact on natural soundscapes in a localized area. As each restoration site is completed, natural sounds would be restored as native species return to the sites. This would improve the natural soundscapes in the restoration areas. The natural soundscape would be restored in more areas in alternatives A and C, and in the same areas but at a faster rate than alternative B.

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	adverse effects on natural soundscapes within the project areas, and within and around transportation corridors (whether flight lines or trails) to the project areas, and the use of stock results in short-term minor adverse effects on natural soundscapes. • Restoration, Monitoring, and Research - Most of the work associated with these activities does not generate noise above a normal speaking voice, resulting in short- to long-term negligible adverse effects on the natural soundscape in localized areas. • Fish Disposal - Most of the work related to fish disposal would not generate noise above a normal speaking voice, resulting in short- to long-term negligible adverse effects on the natural soundscape in localized areas.	frog vocalization in many areas of the parks, would be lost, resulting in a major adverse long-term effect.	slower rate.	the natural soundscape in a localized area. The natural soundscape would be restored in more areas than alternative A, but in fewer areas and at a slower rate than alternatives B and D.	
Visitor and Employee Health and Safety	• Crew Camps – There are risks to employees associated with living in the wilderness, but risks are reduced by proper training and conducting job hazard analyses. There is no effect on public health and safety. • Helicopter and Stock Use – There are risks to employees associated with working around helicopters and stock. These risks are mitigated by proper training and the use of an experienced crew. There is no effect on public health and safety. • Restoration, Monitoring, and Research - Crews working in the wilderness have the potential for accidents and injuries. This risk is mitigated through the implementation of standard practices, conducting job hazard analyses, and training employees on proper procedures. These project components would not affect public health and safety. • Fish Disposal - Crews working in the wilderness have the potential for accidents and injuries. This risk is mitigated through the implementation of standard practices, conducting job hazard analyses, and training employees on proper procedures. These project components would not affect public health and safety.	This alternative would result in no appreciable effect on visitor health and safety. Employee risks are mitigated, but employees still assume personal responsibility for their safety, whether on or off duty. There still could be risks to employee safety until the ongoing project work is completed, but the risks are low to moderate.	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 a negligible threat to the health and safety of wilderness users and the parks' neighbors. For crews, the short-term risk of piscicide treatments is low to moderate, but the piscicide treatments provide a long-term benefit by reducing total exposure from an average of six years (field seasons) per lake treatment site and up to 10 years per sites with long or complex streams (during summer months) to two to four weeks each year over a one to two year period for most sites selected for piscicide treatment, and potentially up to three years for one or more of the largest piscicide treatments. Piscicide treatments increase the risk for crews slightly, but provide a long-term benefit by reducing total time exposed to work hazards.	The effects on visitor health and safety would be the same as alternative A except the duration of the project would be longer, and there would be more sites. In addition, there would be a negligible to low increase in risk to visitors due to blasting (if determined necessary) in up to five locations. The effects of this alternative on employee health and safety would be the same as described under alternative A, though the duration of the project would be longer and there would be more project sites, resulting in a slightly increased risk. In addition, there would be a slight increase in risk for crews performing blasting activities (if determined necessary) in up to five locations. Crew members could spend approximately 6 to 10 field seasons per treatment site for the duration of the project, which is expected to continue for the next 35 years.	The effects of this alternative related to the use of piscicide treatments on visitor health and safety are the same as alternative B. Piscicide treatments increase the risk for crews slightly, but provide a long-term benefit by reducing total time exposed to work hazards from six to 10 years per site, to two to four weeks per site over a one to two year period for most treatments, and potentially up to three years for one or more of the largest treatments.
Visitor Experience and Recreational Opportunities	• Crew Camps - The likelihood of visitors seeing crew camps is slight, and would result in negligible short-term adverse effects to those few park visitors who happen to travel by the site. • Helicopter and Stock Use – The use of helicopters and stock can have a positive or	Visitors may experience a slight change in recreational opportunities as a result of the ongoing program, primarily due to reduced angling opportunities and ecosystem restoration in the 25 treatment waterbodies. Effects would be short- and long-term negligible to minor adverse and beneficial.	Visitors would experience a moderate change in recreational opportunities as a result of expanding the existing program, primarily due to reduced angling opportunities and ecosystem restoration in the 21 additional treatment basins. Visitors to the restored waterbodies should notice the effects associated with this	Visitors would experience a negligible to minor change in recreational opportunities as a result of expanding the existing program, primarily due to reduced angling opportunities and ecosystem restoration in the 17 treatment basins. Visitors to the restored waterbodies should	Impacts would be similar to alternative B except that this alternative would result in a greater number of short-term site closures, and take the least amount of time to complete, meaning that angling would be excluded sooner and opportunities for observing restored ecosystems would improve faster when

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	negative effect on the visitor experience. Generally, the use of helicopters results in a short-term moderate adverse effect. The use of stock results in minor short-term adverse or beneficial effects. • Restoration, Monitoring and Research –The effects are negligible to minor and adverse, but as ecosystems are restored, the effects would be long-term and beneficial. • Fish Disposal –The presence of dead fish would result in short-term negligible to minor adverse effects.		alternative. Effects would be short- and long-term minor to moderate and adverse and beneficial.	notice the effects associated with this alternative. Effects would be short- and long-term minor to moderate and adverse and beneficial.	compared to the other alternatives.

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CHAPTER 3 - AFFECTED ENVIRONMENT

INTRODUCTION

This chapter provides a summary of the resources of SEKI that could be affected as a result of implementation of any of the proposed action alternatives in this Restoration Plan/FEIS. The resource descriptions provided in this chapter serve as the baseline from which to compare the potential effects of the management actions considered in this Restoration Plan/FEIS. This chapter is organized by impact and resource topics that were derived from internal park and external public scoping, and is limited to those topics that may be affected by the proposed alternatives.

LOCATION AND GENERAL DESCRIPTION OF PROJECT AREAS

All of the proposed restoration areas would occur within the elevation range of 10,000 to 12,000 ft (3,000 to 3,700 m) in SEKI, with the exception of one proposed nonnative fish eradication area located from 6,000 to 7,000 ft (1,800 to 2,100 m), and one proposed fishless conservation area located at 8,500 ft (2,600 m). In these high elevation areas, there are approximately 3,500 high elevation lakes, ponds, and marshes (waterbodies; Knapp R., unpublished data), and > 1,000 mi (1,600 km) of rivers and streams, including portions of the headwaters of the Kaweah, Kern, Kings, San Joaquin and Tule Rivers. The majority of these waterbodies – approximately 2,500 – are ponds (< 2.5 ac/1 ha), many of which are very small, only holding snowmelt water during early summer and drying completely during late summer (~1,000 are < 0.25 ac/0.1 ha). Approximately 1,000 waterbodies are lakes (2.5 ac/1 ha or larger), all of which currently hold water year-round that can sustain native species such as MYLFs. In addition, many of the lakes are large (~600 are 5 ac/2 ha or larger), which can provide native species with reliable habitats that will buffer drying and warming expected over time due to climate change.

Although all of SEKI's high elevation waterbodies were naturally fishless, surveys completed from 1997 to 2002 (Knapp R., unpublished data) determined that self-sustaining nonnative fish populations had become established in 575 waterbodies. A total of 25 waterbodies that contained nonnative fish were previously approved for fish eradication (NPS 2001, 2009A), and thus 550 waterbodies that contain nonnative fish are potential candidates for additional fish eradication. From these 550 potential candidates, 85 waterbodies (31 lakes, 49 ponds, 5 marshes), or 15% of the remaining waterbodies that contain nonnative fish, were selected for analysis in this Restoration Plan/FEIS (Table 9, Table 10 and Table 11; Figure 7).

The proposed restoration areas occur from the montane to the subalpine and alpine zones of the parks. The montane zone (5,000 to 9,000 ft / 1,500 to 2,700 m) primarily consists of mixed conifer forests that include ponderosa pine (*Pinus ponderosa*), Jeffrey pine (*Pinus jeffreyi*), sugar pine (*Pinus lambertiana*), incense cedar (*Calocedrus decurrens*), white fir (*Abies concolor*) and groves of giant sequoia (*Sequoiadendron giganteum*). The montane zone also contains numerous wet meadows. These meadows may be isolated, but the larger meadows generally have streams flowing through them. Some of these streams originate in the montane zone, while other streams originate at much higher elevations.

Moving up into the lower reaches of the subalpine zone, Jeffrey pine, red fir (*Abies magnifica*), western white pine (*Pinus monticola*), and lodgepole pine (*Pinus contorta*) become increasingly characteristic of the vegetation up to about 10,000 ft (3,000 m). In the upper reaches of subalpine zone (10,000 to 11,500 ft / 3,000 to 3,500 m), the dominant forest becomes stands of foxtail pine (*Pinus balfouriana*), whitebark pine (*Pinus albicaulis*) and lodgepole pine. Therefore, from approximately 9,000 to 11,500 ft (2,700 to 3,500 m), the landscape varies from subalpine forest to open alpine fell-field, prairie, meadow and sparse rocky areas. Above 11,500 ft (3,500 m), the vegetation is primarily open alpine country.

The majority of the project area is dominated by granitic rock, although there are some areas composed of metamorphic rock such as schist and marble. Soils in most of the project areas are shallow to non-existent and poorly developed, with the exception of the forested lower elevations.

GENERAL OVERVIEW OF HIGH ELEVATION AQUATIC ECOSYSTEMS

High elevation aquatic ecosystems (6,000 to 13,000 ft / 1,800 to 4,000 m) in SEKI encompass a variety of habitats, including lakes, ponds, marshes, streams, wet meadows and riparian areas in montane, subalpine and alpine zones, and thus support a variety of wildlife. Lakes, ponds, and marshes in SEKI generally occur from 8,000 to 13,000 ft (2,400 to 4,000 m), with the majority occurring from 10,000 to 12,000 ft (3,000 to 3,700 m; Knapp R., unpublished data). SEKI's high elevation basins range from containing less than five lakes and ponds to approximately 100 lakes and ponds, most of which are connected by streams or lie in close proximity to each other. Sometimes marshes occur on the fringes of lakes, ponds and streams; and wet meadows or stands of willows are often present, either adjacent to lakes and streams or existing by themselves. Collectively, the lakes, ponds, marshes, streams, wet meadows, and riparian areas within these basins provide habitat that many native wildlife need to survive.

Because of expected climate warming, waterbodies above 10,000 ft (3,000 m) may become increasingly important aquatic habitat in the future, especially larger, deeper and/or colder lakes that would persist during long drought periods and/or provide a buffer to expected increases in water temperature. Eighteen of the 85 waterbodies proposed for fish eradication in alternative B (or 21%) are at least 5 ac (2 ha) in surface area and 16 ft (5 m) in maximum depth. In addition, all of the basins proposed for fish eradication would see habitat improvement in the form of increasing the amount of fishless habitat available in close proximity to existing (or recently extirpated) MYLF populations.

Due to the presence of (1) primarily unweathered granitic rock, (2) sparse vegetation, and (3) short summer growing seasons, high elevation aquatic ecosystems in SEKI are typically low productivity systems that support relatively simple food webs. In its naturally fishless condition (Figure 11), phytoplankton (algae), aquatic and terrestrial plants, and detritus are positioned at the base of the food web. Phytoplankton species are grazed by a diverse mix of large and small zooplankton species, aquatic invertebrate larvae, and amphibian larvae (tadpoles). Zooplankton species are primarily consumed by other zooplankton species and aquatic invertebrates. Aquatic invertebrates, and terrestrial invertebrates that temporarily enter water, are consumed by amphibians, birds, insects and mammals. Amphibian larvae, juveniles, and adults are consumed by certain species of snakes, birds, and mammals, while typically only amphibian eggs and larvae are consumed by invertebrate predators.

Nutrients and energy are thus transferred through SEKI's high elevation aquatic ecosystems in a complex food web. Particularly important trophic connections occur during the summer growing season in and around waterbodies that have retained their naturally fishless condition (Harper-Smith et al. 2005, Finlay and Vredenburg 2007). First, in early summer, populations of amphibians including both species of MYLFs and the Pacific treefrog produce a large number of tadpoles in waterbodies where there is good breeding habitat. Some of these tadpoles survive to metamorphose into juvenile frogs, and then some of these juvenile frogs survive to adulthood. However, the majority of tadpoles and juvenile frogs are consumed by various aquatic and terrestrial predators, which transfers substantial energy and nutrients to many parts of the food web.

Second, aquatic invertebrates such as mayflies "hatch" in a concentrated manner over several days in waters that provide good breeding habitat. In early summer, hundreds to thousands of larvae swim to the water surface, metamorphose into winged adults, and breed while flying above the water. During these hatches, birds, such as the gray-crowned rosy finch, and bats prey on this rich food source, transferring substantial energy from aquatic to terrestrial ecosystems.

In high elevation waterbodies that contain nonnative fish populations these important trophic connections are severed (Harper-Smith et al. 2005, Finlay and Vredenburg 2007). Nonnative fish (various trout species) instead consume much of the biomass generated by the aquatic ecosystem (Figure 11) reducing the availability of food for native species. Being visual predators, nonnative fish selectively prey on large-bodied organisms, including amphibians, large zooplankton, and aquatic and terrestrial insects, and either eliminate or severely deplete these populations. Thus, waterbodies containing nonnative fish have fewer native species (Knapp et al. 2001, Knapp 2005A) and generate less biomass (Finlay and Vredenburg 2007) than waterbodies that have retained their naturally fishless condition. In addition, the presence of nonnative fish in lakes and especially streams inhibits MYLFs from migrating between different waterbodies in a basin and between basins, and thus cause MYLF populations to be fragmented and isolated from one another (Bradford et al. 1993). Natural function is therefore highly disrupted in high elevation aquatic ecosystems containing nonnative fish.

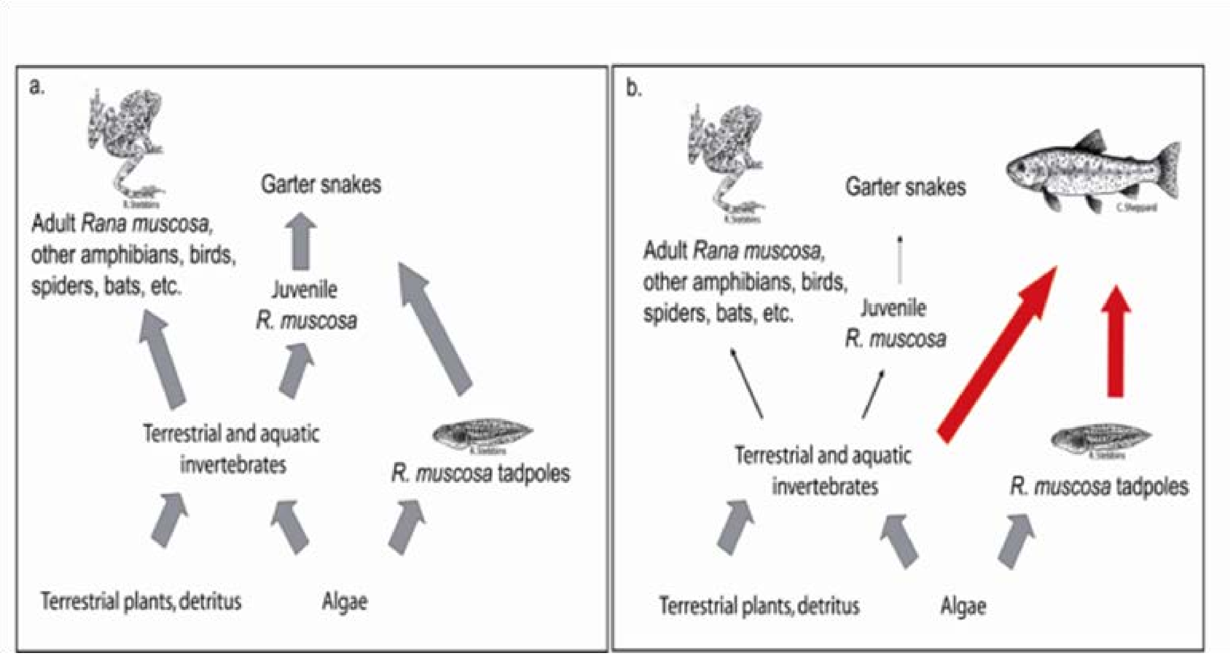

Figure 11. Trophic connections found in high elevation waters in the Sierra Nevada

Figure 11 shows trophic connections found in waters that have retained their naturally fishless condition (diagram on left) and waterbodies containing nonnative fish (diagram on right). The width of each arrow shows the amount of biomass in each trophic connection; wide arrows represent a large amount of biomass and thin arrows represent a small amount of biomass. Courtesy of Finlay and Vredenburg (2007).

SPECIAL-STATUS SPECIES

The special-status species include species that are federally or state listed, and other species of concern within the project area that are rare or otherwise merit special consideration (appendix F). Species potentially affected by the alternatives include MYLFs (*Rana muscosa and Rana sierrae*), the Yosemite toad (*Anaxyrus [Bufo] canorus*), the Sierra Nevada bighorn sheep (*Ovis canadensis sierrae*) and the Little Kern golden trout (*Oncorhynchus mykiss whitei*).

Mountain Yellow-Legged Frogs

MYLFs are a native amphibian species complex within SEKI that includes two species (Vredenburg et al. 2007): the Sierra Nevada yellow-legged frog (*Rana sierrae*) and southern mountain yellow legged-frog (*Rana muscosa*). Both species are federally listed as endangered, while *R. sierrae* is state listed as threatened and *R. muscosa* is state listed as endangered (CDFW 2012, FWS 2014A). Both species are of management concern to the NPS. Occupied and unoccupied habitat occurs within the proposed treatment areas.

Their natural habitats are mountain lakes, ponds, marshes and streams at elevations of 4,500 to 12,000 ft (1,400 to 3,700 m). Due to the fact that they overwinter in waterbodies and their tadpoles take multiple years to develop, MYLFs require waterbodies that do not freeze solid in the winter or dry out in the summer. Open lake and stream edges with a gentle slope seem to be preferred. They are most active during the day. Within SEKI, the range of *R. sierrae* is generally bordered by ridges that divide the Middle and South Forks of the Kings River and ranges from Mather Pass, west to the Monarch Divide and north to the northern boundary of Kings Canyon National Park, while the range of *R. muscosa* is generally bordered by the crest of Sierra Nevada with the ridges that divide the Middle and South Forks of the Kings River, and ranges from Mather Pass, west to the Monarch Divide, and south to the southern boundary of Sequoia National Park (Vredenburg et al. 2007).

These species only occur in high elevation waterbodies of the Sierra Nevada and southern California and were thought to be the most abundant vertebrates in these systems (Grinnell and Storer 1924), providing critical ecological function as predator, prey and agents of energy and nutrient cycling between aquatic and terrestrial ecosystems (Finlay and Vredenburg 2007). Within the lower elevation montane zone, MYLFs were reported from wet meadows, but streams probably provided the necessary areas for over-wintering and connectivity to other meadows (Pope and Matthews 2001). In SEKI, MYLFs disappeared from these areas in the mid-1900s (Jennings and Hayes 1994).

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). Studies in the past decade, however, determined that MYLF populations have disappeared from approximately 92% of historic localities in the Sierra Nevada, with similarly large losses in 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). Due to this steep decline, *R. muscosa* and *R. sierrae* are now federally listed as endangered throughout their entire range (FWS 2014A).

The amphibian chytrid fungus is a recently discovered fungal pathogen (Longcore et al. 1999) that 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. 2010A) and has infected nearly all remaining MYLF populations in SEKI. Most MYLF populations severely declined within a few years after becoming infected and many populations have gone extinct. Amphibian chytrid fungus has thus been a major factor in accelerating the decline of MYLFs initially caused by the presence of nonnative fish throughout the Sierra Nevada.

Amphibian chytrid fungus is not well understood and is currently being investigated in several studies. A few MYLF populations are showing evidence of persistence – surviving and reproducing while continuing to be infected (Vredenburg et al. 2010A, NPS unpublished data). 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 the resulting population recovery should increase their chances of long-term persistence.

Air pollution has also been implicated in the MYLF decline by depositing contaminants into aquatic habitat, which may make MYLFs more susceptible to disease (Davidson et al. 2002, Davidson and Knapp 2007, Fellers et al. 2007). However, most studies have involved few direct measurements of pesticide concentrations in the field, but instead have made inferences based on correlative factors such as wind patterns and assumed pesticide drift (Davidson 2004, Davidson and Knapp 2007). More recent research in high elevations of the southern Sierra Nevada directly measured the field concentrations of 9 pesticide compounds at multiple sites and found no support for the hypothesis that pesticides have contributed to MYLF declines (Bradford et al. 2011). Global climate change has been implicated in drying up critical breeding habitat in one MYLF population (Lacan et al. 2008), and may have more impact in the future. Although these regional and global threats are outside the direct control of SEKI, they can be mitigated through the choice of strategic treatment waterbodies.

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. 2010A, 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; Knapp et al. 2005). For a complete life history of MYLFs, see appendix J.

Although SEKI has improved MYLF populations in several areas from which fish were eradicated (Vredenburg 2004, NPS 2015A), all remaining MYLF populations are still extremely vulnerable to extirpation due to multiple threats and thus are in urgent need of intervention. First, many populations occupy large basins in which multiple large lakes contain nonnative trout and MYLFs are restricted to small and/or shallow ponds. The trout severely limit frog distribution and abundance by excluding them from large amounts of lake habitat, while at the same time restricting them to pond habitat that is highly vulnerable to climate change. These ponds can completely dry up in even relatively short droughts as has already occurred in SEKI (Lacan et al. 2008). When this happens, multiple cohorts of MYLF tadpoles are lost, and populations already suppressed by trout can be quickly extirpated. In addition, shallow ponds can freeze solid during atypical climate patterns as occurred in SEKI during the winter of 2011 to 2012. This event appears to have killed most of the adult MYLFs that remained in one park basin. Eradicating nonnative trout as quickly as possible in such areas would allow MYLF populations to expand (Knapp et al. 2007) and recolonize large lake habitat that is much more protected from climate effects.

Second, nearly all remaining MYLF populations in areas feasible for restoration in SEKI are infected with amphibian chytrid fungus. MYLF populations in SEKI restored in the recent past were disease-free and primarily being suppressed only by nonnative trout. Eradicating trout then allowed the MYLF populations to easily expand in size because amphibian chytrid fungus and its subsequent impacts were not yet present (Knapp et al. 2007). Now, however, as the amphibian chytrid fungus has spread throughout much more of the landscape, many of SEKI's MYLF populations have experienced severe die-offs and the surviving remnant populations have very low survival and recruitment from year to year. These small frog populations are thus extremely vulnerable to extirpation. In addition to trout removal, these MYLF populations would likely benefit from an emerging disease treatment technique using antifungal agents, designed to increase short-term survival and hopefully long-term recruitment, thus changing the outcome for many frogs from mortality to persistence. Preliminary results of several field trials conducted in SEKI from 2009 to 2015 show promise for future management application.

Yosemite Toad

The Yosemite toad (*Anaxyrus [Bufo] canorus*) is currently listed as threatened (FT) under the federal Endangered Species Act (FWS 2014A) and is a California species of special concern. Yosemite toads are known to occur in or near two proposed treatment areas (McGee and Upper Evolution Basins; USGS unpublished data).

The Yosemite toad is endemic to high elevations in the Sierra Nevada from Ebbetts Pass at the southern boundary of Eldorado National Forest in Alpine County to the Blue Canyon area in northern Kings Canyon National Park in Fresno County. Recent surveys of suitable Yosemite toad habitat in Kings Canyon National Park have documented the species in approximately 42 meadows (Knapp R., unpublished data, USGS unpublished data).

The Yosemite toad has been found in a wide variety of high montane, subalpine, and alpine lentic habitats. However, it is most commonly found in shallow, warm water areas, including small permanent and ephemeral ponds usually located in meadows, and shallow flooded meadow vegetation adjacent to lakes and streams (Mullally 1953, Karlstrom 1962, Kagarise Sherman 1980, Knapp R., unpublished data). Toads require a combination of habitat types to support their life history stages, including breeding, rearing, foraging, dispersal, and overwintering habitat. Breeding and rearing takes place in shallow ponds, slow moving streams, marshes, and along shallow protected shores of lakes, that are components of open wet meadows or moist riparian areas dominated by short emergent sedges and exposed to ample sunlight (Karlstrom 1962, Kagarise Sherman 1980). Water depth and water temperature appear to be important limiting factors in the survival of eggs and larvae (Kagarise Sherman and Morton 1993). Suitable breeding habitats are often warmer than other aquatic components in the landscape. Tadpoles tend to aggregate in warm, shallow water where higher temperatures increase the rate of development (Kagarise Sherman 1980, Jennings and Hayes 1994).

Yosemite toads are generally inactive from early-October until mid-May to early-June, typically hibernating under snow in rodent burrows or crevices under rocks or bushes (Karlstrom 1962; Kagarise Sherman and Morton 1984). Depending on elevation and amount of snowfall the previous winter, Yosemite toads may breed in early-May through July (Kagarise Sherman 1980). Eggs hatch in 4 to 6 days and tadpoles metamorphose into juveniles in about 48 to 63 days (Karlstrom 1962, Kagarise Sherman 1980). Juveniles appear to remain in their natal meadow for their first year (Brown C., pers. comm., 2012) and juveniles and adults are often found in moist meadow habitat where they forage. Willow thickets and springs and seeps in adjoining uplands and forests are also important features of dispersal and overwintering habitat (Kagarise Sherman 1980, Martin 2008). Natural meadow depressions, cavities, and holes, such as those created by deer hooves or rodents, or crevices near boulders or logs and vegetation such as willow thickets, provide temporary cover and refuge for juvenile and adult toads. Rodent burrows are important habitat features and serve as overwintering sites as well as temporary summer refugia (Mullally and Cunningham 1956, Karlstrom 1962, Kagarise Sherman 1980, Martin 2008).

Yosemite toads were once a common species in the Sierra Nevada. Estimates suggest that the toad has disappeared from between 47% and 79% of the sites that it previously occupied (Jennings and Hayes 1994, Jennings 1996, Drost and Fellers 1994, 1996). Remaining populations appear more scattered across the landscape and consist of a small number of breeding adults (Kagarise Sherman and Morton 1993). Because of its historic abundance, the toad was likely an important link in energy and nutrient cycling within meadow ecosystems. Therefore, past and predicted future losses of the toad could impact food webs and nutrient cycling with potentially significant and important consequences for Sierra Nevada high-elevation wet meadow ecosystems.

Multiple factors, individually and likely through a variety of complex interactions, may have contributed to the toad’s decline. Recreational activities (including pack stock grazing), infrastructure (roads and trails), nonnative fishes, climate change, disease (including chytridiomycosis), air pollution, UV-B radiation, and drought are among the factors that have been identified as potentially impacting this species and its habitat (FWS 2008A). Introduced fish may be having a continuing impact on the toad populations.

Grasso et al. (2010) found the larvae to be unpalatable to introduced brook trout. However, in the Golden Trout Wilderness, Roland Knapp observed closely related western toad (*Anaxyrus boreas*) juveniles in the stomach contents of introduced golden trout (Knapp R., pers. comm., 2013). Fish are often not a concern since the toads breed primarily in ephemeral areas where fish are not present (Drost and Fellers 1994). During drought years, Yosemite toads have been documented shifting their breeding sites from ephemeral ponds to streams (FWS 2008A). This ensures an adequate water supply but increases exposure to introduced trout. Introduced fish may also impact the toads by increasing exposure to diseases. Both viral (Mao et al. 1999) and fungal (Blaustein et al. 1994A) pathogens have been known to be shared by both fish and amphibians.

Sierra Nevada Bighorn Sheep

Sierra Nevada bighorn sheep (*Ovis canadensis sierrae*) inhabit portions of the Sierra Nevada located along the eastern boundary of California in Tuolumne, Mono, Fresno, Inyo, and Tulare Counties. Habitat occurs from the eastern base of the range as low as 4,790 ft (1,460 m) to peaks above 14,100 ft (4,298 m) (Wehausen 1980). Proposed treatment sites in Sixty Lake Basin and Laurel Creek would be located in designated critical habitat.

It has been estimated that prior to European settlement there were more than 1,000 bighorn sheep in the Sierra Nevada (FWS 2007B). However, the Sierra bighorn population was severely reduced during the 19th and 20th centuries apparently because of diseases from domestic sheep, forage competition with domestic livestock, and market hunting. The FWS issued an emergency ruling to list the Sierra Nevada population of California bighorn sheep (now termed the subspecies *O. c. sierrae)* as endangered on April 20, 1999. On January 3, 2000, the FWS published a final rule listing the Sierra Nevada bighorn sheep as Endangered (FWS 1999). Critical habitat for this species was designated on August 5, 2008 (FWS 2008B) and some portions of SEKI's high elevations have been designated as critical habitat for this species (Figure 12). Since their listing under the ESA, the Sierra Nevada bighorn sheep population has grown from about 125 individuals in 1999 to about 400 in 2010 (CDFW 2012; http://www.dfg.ca.gov/snbs/RecoveryHome.html).

Sierra Nevada bighorn sheep inhabit the alpine and subalpine zones during the summer, using open slopes where the land is rough, rocky, sparsely vegetated, and characterized by steep slopes and canyons (Wehausen 1980). Most of these sheep live between 10,000 ft (3,000 m) and 14,000 ft (4,300 m) in elevation in the summer. In the winter, they occupy high, windswept ridges, or migrate to the east slope lower elevation sagebrush-steppe habitat as low at 4,800 ft (1,500 m) to escape deep winter snows and find more nutritious forage. Bighorn sheep tend to exhibit a preference for warmer, south facing slopes in the winter. Lambing areas are on precipitous rocky slopes where there is relative safety from predators. They select open terrain adjacent to steep slopes where they are better able to see predators and flee to safety (lambing occurs between late April to early-July with most lambs born in May or June). Ewes and lambs frequently occupy steep terrain that provides a diversity of slopes and exposures for escape and cover (Wehausen 1980).

One of the proposed treatment sites would be in the lower portion of Sixty Lake Basin (Figure 12). Bighorn sheep critical habitat is located in the upper portion of this basin and sheep have recently been observed in this area. The proposed treatment site involves approximately seven lakes, and connective ponds and streams in the lower end of the basin. Fish eradication in Laurel Creek (appendix B) would occur primarily in stream habitat, plus one pond. There had not been any bighorn sheep activity observed in the area in more than a century; however, it is designated critical habitat and sheep were reintroduced into Laurel in 2015 as one of the targeted actions in the recovery plan (FWS 2007B, NPS 2011B).

Little Kern Golden Trout

Little Kern golden trout (*Oncorhynchus mykiss whitei*) is a subspecies of rainbow trout that is endemic to the Little Kern River drainage of Tulare County, California. The Little Kern River drainage occurs primarily in the Golden Trout Wilderness of Sequoia National Forest with smaller areas of the drainage in Sequoia National Park. The Little Kern golden trout is listed as threatened under the federal ESA (FWS 1978). Little Kern golden trout occur in one proposed treatment area (Crytes Basin; NPS unpublished data) included in this plan.

Hybridization with nonnative salmonids is the most imminent threat to the Little Kern golden trout. Rainbow trout were introduced to the Little Kern basin beginning in the early 1930s or possibly earlier (Christenson 1984). Rainbow trout readily hybridized with Little Kern golden trout, producing fertile offspring (Gall et al. 1976). As a result of the introductions, genetic integrity of this subspecies was compromised, reducing the number of genetically pure populations and reducing the subspecies range. At the time of listing, pure populations were thought to only persist in the upper-most headwater reaches of five tributaries to the Little Kern River and management efforts focused on piscicide eradication of introgressed (genetically compromised) populations and restocking of genetically pure Little Kern golden trout between 1975 and 1996 (FWS 2011). Restoration efforts have largely been successful in removing severely introgressed populations of Little Kern golden trout and the broader influence of nonnative fishes (e.g., brook trout). However, the hybridization with nonnative rainbow trout is still likely to be an issue. In addition, reestablished populations are showing signs of low genetic diversity (Stephens 2007) making these populations more vulnerable to stochastic events and/or climate change (FWS 2011).

The population of Little Kern golden trout in Crytes Basin is not native to that area. In 1887, a number of Little Kern golden trout from within their natural range were transplanted to historically fishless habitat in Crytes Basin (Ellis and Bryant 1920). Since this basin is outside of the natural range of Little Kern golden trout, it was not designated as critical habitat (FWS 1978) and is not part of the official recovery plan for the species (Christenson 1984). In addition, recent genetic analysis shows that this population is not genetically-pure (Stephens et al. 2005, Deiner et al. 2010, Erickson et al. 2010). Genetic data were derived from tissue samples collected from dozens of fish during several sampling events in the last decade. Results show that this population has retained Little Kern golden trout characteristics, but has also acquired significant admixture with rainbow trout and California golden trout, possibly from undocumented transplant into Crytes Basin after the original 1887 introduction. As a result, this population now contains introgressed Little Kern golden trout. 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.

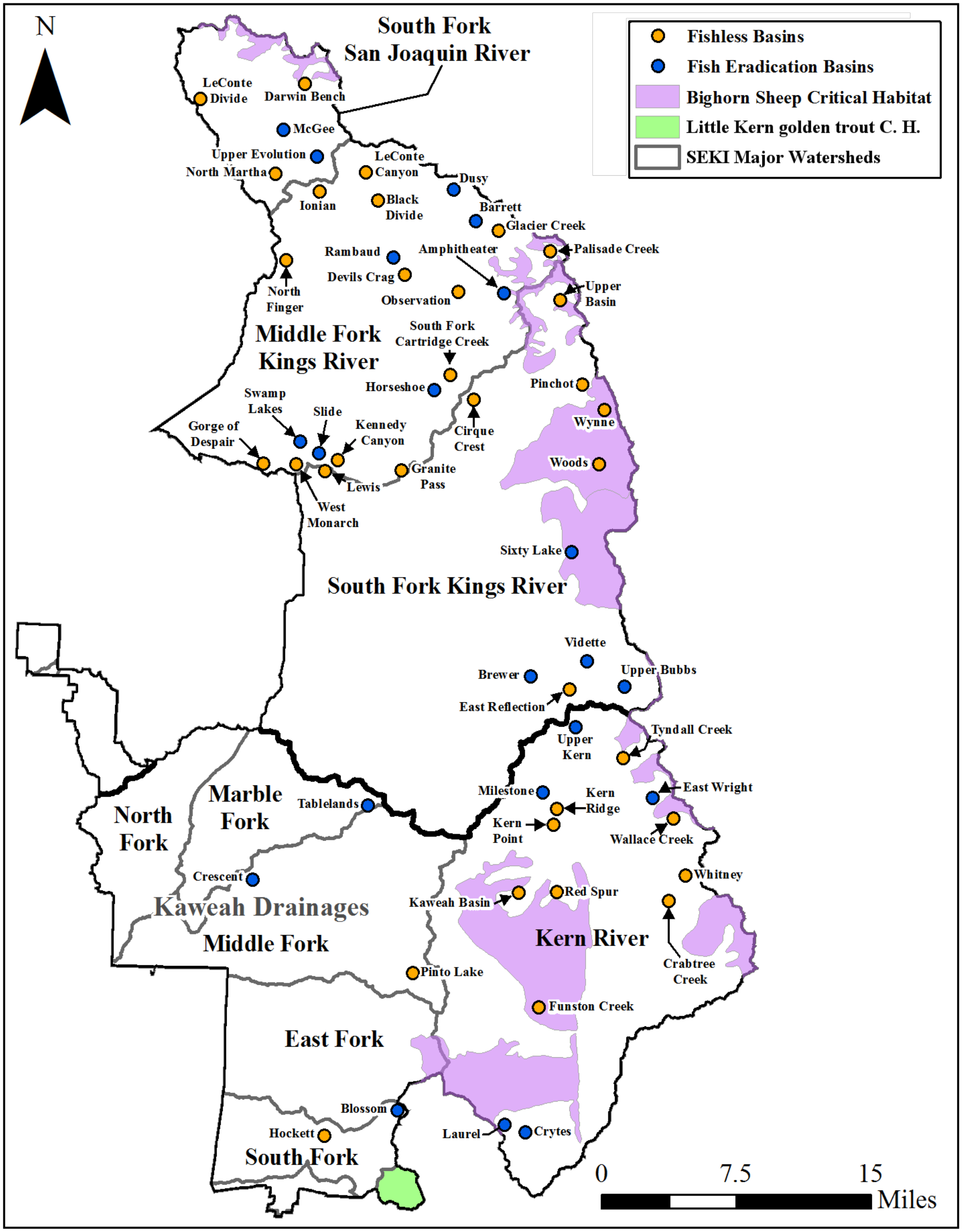

Figure 12. Map showing locations of proposed fish eradication basins (in blue)
Additional native species conservation basins are shown in orange, in relation to critical habitat (C. H.) designated for federally listed Sierra Nevada bighorn sheep (in purple) and Little Kern golden trout (in green).

WILDLIFE

Native Vertebrates

The native vertebrates that occur in SEKI's high elevation aquatic ecosystems are well known from surveys, studies and observations recorded over roughly the last 100 years. These species include a diverse assemblage of amphibians, reptiles, birds and mammals. The native vertebrates that occur in the project area and that could be measurably affected by actions proposed in this Restoration Plan/FEIS are shown in Table 18.

Mountain and Sierra garter snakes consume amphibians, fish, birds, mice, lizards, snakes, worms, leeches, slugs and snails. Adult Pacific treefrogs consume a wide variety of insects, primarily on the ground at night, but also flying insects, many of which emerge from aquatic larval stages. Pacific treefrog tadpoles are suspension feeders, eating a variety of prey including algae, bacteria, protozoa and organic and inorganic debris. Tadpoles are gill-breathing amphibian larvae that occur in the project area, along with larval benthic macroinvertebrates, zooplankton and nonnative fish.

All of the bird and bat species primarily consume insects as they emerge from their larval stage in aquatic environments. However, Brewer's blackbirds have been documented to feed on MYLFs (Bradford 1991); and Brewer's blackbirds, Clark's nutcrackers, and American robins have been observed to feed on MYLFs in SEKI, in populations that expanded due to fish eradication in the last decade (NPS 2012A).

Northern water shrews feed on aquatic and terrestrial invertebrates, tadpoles, fish eggs, fish, carrion, and other shrews, and were observed feeding on MYLF tadpoles in a completed SEKI fish eradication lake (Boiano, D. pers. obs., 2015). Coyotes have been documented to feed on MYLFs (Jennings and Hayes 1994), and were observed periodically visiting the shorelines of waterbodies in the project area, opportunistically preying on nonnative fish (NPS 2012A).

All of the amphibian, snake and bird species, and the northern water shrew frequent lakes and streams to forage and are small enough to have the potential to get caught in gill nets.

Although mountain and Sierra garter snakes have a very generalist diet, in the high Sierra Nevada they are much more likely to be associated with lakes that contain amphibians (Matthews et al. 2002), and primarily feed on Pacific treefrogs (Jennings et al. 1992) and MYLFs (Matthews et al. 2002). Sierra garter snakes) are capable of moving many kilometers following spring emergence (Gregory and Stewart 1975, Larsen 1987). Although such long distance movements are not typical (Macartney et al. 1988), *Thamnophis* species can generally cover large areas during active periods (Macartney et al. 1988).

Table 18. Native vertebrates that occur in the project area and could be measurably affected

Common Name	**Latin Name**
Pacific treefrog	*Pseudacris regilla*
Mountain garter snake	*Thamnophis elegans elegans*
Sierra garter snake	*Thamnophis couchi*
American dipper	*Cinclus mexicanus*
Gray-crowned rosy finch	*Leucosticte tephrocotis*
Clark's nutcracker	*Nucifragra columbiana*
Brewer's blackbird	*Euphagus cyanocephalus*
American robin	*Turdus migratorius*
Spotted sandpiper	*Actitis macularius*
Eared grebe	*Podiceps nigricollis*
Northern water shrew	*Sorex palustris*

Coyote	*Canis latrans*
*Big brown bat	*Eptesicus fuscus*
*Spotted bat	*Euderma maculatum*
*Western mastiff bat	*Eumops perotis*
*Hoary bat	*Lasiurus cinereus*
*Little brown myotis	*Myotis lucifugus*
*Small-footed myotis	*Myotis leibii*
*Yuma myotis	*Myotis yumanensis*
*Brazilian free-tailed bat	*Tadarida brasiliensis*

** The eight bat species listed above include all bats that have been captured or recorded in the project area, and that either feed over aquatic habitats or are generalists feeders (Pierson and Rainey 2009), making it possible for them to occur over treated habitat and therefore to be affected by proposed actions.*

Invertebrates

A full census of invertebrates has not been completed within SEKI, however, several studies have surveyed for invertebrates in many high elevation waterbodies in these parks (Kubly 1983, Stoddard 1987, Bradford et al. 1998, Knapp et al. 2001, Knapp R., unpublished data, Herbst et al. 2009, Finlay and Vredenburg 2007). These studies identified many species and documented the presence of a diverse invertebrate assemblage. The species described in this section generally occur in the project area, but not all have been documented in all project locations (i.e., every waterbody proposed for fish eradication or native species conservation).

Numerically, invertebrates are the most abundant wildlife in the project area. The invertebrate communities include (1) zooplankton that live in the water column of lakes and ponds, (2) benthic macroinvertebrates that live on lake and stream bottoms or near the surface of waters, and (3) terrestrial and aquatic invertebrates that live in marshes and wet meadows on the edges of lakes, ponds and streams.

Zooplankton

Zooplankton consists primarily of microcrustaceans (water fleas, copepods, and fairy shrimp) and rotifers (microscopic or very small animals that move with a spinning-like motion). Stoddard (1987) identified five unique communities of microcrustaceans in the Sierra Nevada. The first two communities are associated with the presence of fish. Two additional communities live in waterbodies without fish, including one in deep water and the other in shallow sites. These include large-bodied species that are particularly susceptible to predation by fish. Stoddard's fifth community (characterized by the presence of *Chydorus* cf. *sphaericus* and *Alona affinis*) showed no relationship to fish presence or absence, but occur at sites where phosphate values were highest. The most common species that characterize these five unique zooplankton communities in SEKI are shown in Table 19.

Table 19. The most common zooplankton species known to occur in SEKI

Common Name	Latin Name
Associated with fish-containing waterbodies - high elevation	
water flea	*Daphnia dentifera*
Copepod	*Leptodiaptomus signicauda*
water flea	*Bosmina longirostris*
water flea	*Holopedium gibberum*
Associated with fish-containing waterbodies - lower elevation	
water flea	*Daphnia dentifera*
Copepod	*Leptodiaptomus signicauda*
water flea	*Bosmina longirostris*

water flea	*Holopedium gibberum*
water flea	*Ceriodaphnia affinis*
water flea	*Polyphemus pediculis*
microcrustacean	*Diaphanasoma brachyurum*
Copepod	*Cyclops vernalis*
Associated with fishless waterbodies – deep water	
Copepod	*Hesperodiaptomus shoshone*
water flea	*Daphnia melanica*
Associated with fishless waterbodies – shallow water	
Copepod	*Hesperodiaptomus eiseni*
water flea	*Daphnia melanica*
fairy shrimp	*Branchinecta dissimilis*
No fish relationship – high phosphate water	
water flea	*Chydorus cf sphaericus*
water flea	*Alona affinis*

Aquatic Invertebrates

In lakes and ponds, the benthic (bottom dwelling) invertebrates consist primarily of mollusks, insects, amphipods (*Hyalella*), fairy shrimp (*Branchinecta oriena*), water mites (*Hydracarina*), nematodes, and oligochaetes (Knapp et al. 2005). The mollusks include a small bivalve (*Pisidium),* and sometimes a small freshwater limpet (*Ferrissia)*. The insect fauna is more complex. Water boatmen (Corixidae - *Cenocorixia*), and backswimmers (Notonectidae - *Notonecta*), predaceous diving beetles (Dytiscidae – *Hydroporus, Laccophilus, Oreodytes, Rhantus*) and leeches (Glossiphiniidae – *Helobdella*) search for prey both along the bottom and move through the water column. Mayfly (Ameletidae - *Ameletus edmundsi*, Baetidae - *Callibaetis ferrugineus*) and caddisfly larvae (Limnephilidae - *Desmona, Limnephilus,* Sericostomatidae - *Gumaga*, Calamoceratidae - *Heteroplectron*, Leptoceridae -*Mystacides*) occupy the top of the substrate along with stonefly (Chloroperlidae – *Alloperla*, *Neaviperla*) and dragonfly larvae (Aeshnidae - *Aeshna*). Buried in the substrate are fly (Ceratopogonidae, Chironomidae) and alderfly larvae (Sialidae - *Sialis*). Usually near the water surface are mosquitos (Culicidae – *Culista*) whirligig beetles (Gyrinidiae – *Gyrinus*) and water striders (Gerridae – *Aquarius, Gerris, Limnophorus*).

In alpine/subalpine streams, the benthic invertebrates consist primarily of insects, but also includes mollusks (*Pisidium*), seed shrimp (*Ostracoda*), water bears (*Tardigrada*), flatworms (*Tricladida*), mites (*Hydrachnidia, Oribatei*) and oligochaetes (Melack et al. 1989, Herbst et al. 2009).

The most-common aquatic invertebrates that are known or expected to occur in high elevation streams in SEKI are shown in Table 20.

Table 20. The most common aquatic invertebrates known to occur in SEKI's high elevation streams

Alpine/Subalpine and Montane Streams	
Common Name	**Latin Name**
Mayflies	Baetidae – *Baetis, Diophetor*; Heptageniidae – *Cinygmula, Epeoris, Rithrogena*; Ephemerellidae – *Drunella spinifera, Serratella*; Leptophlebiidae – *Paraleptophlebia*), stoneflies (Perlidae – *Doroneuria baumanni*; Pteronarcyidae – *Pteronarcys*; Nemouridae – *Malenka, Nemora, Zapada*; Capniidae; Perlidae – *Claassenia sabulosa*; Perlodidae – *Cultus, Isoperla*; Chloroperlidae – *Alloperla, Sweltsa, Suwallia*; Nemouridae – *Soyedina, Zapoda*
Caddisflies	Hydropsychidae – *Hydropsyche*; Rhyacophilidae – *Rhyacophila*; Arctopsychidae – *Parapsyche*; Apataniidae – *Apatania*; Brachycentridae – *Amiocentrus, Micrasema*;

	Limnephilidae – *Desmona, Chyranda centralis, Psychoglypha, Dicosmoecus, Ecclisomyia, Hesperophylax*; Helicopsychidae – *Helicopsyche*
Flies	Tipulidae – *Dicranota, Limonia*; Dolichopodidae – *Dolichopus*; Empididae – *Clinocera, Chelifera*; Culicidae – *Culiseta incidens*; Ceratopogonidae – *Bezzia, Culicoides, Monohelea, Atrichopogon, Forcipomyia*; Simulidae – *Prosimulium, Simulium, Metacnephia, Stegopterna*; and the abundant Chironomidae – *Parochlus, Diamesa, Pagastia, Monodiamesa, Thiennemannimyia, Ablabesmyia, Apsectrotanypus, Larsia, Helopelopia, Krenopelopia, Trissopelopia, Zavrelimyia, Brillia, Corynoneura, Cricotopus-Orthocladius, Diplocladius, Eukiefferiella, Heterotrissocladius, Heleniella, Hydrobaenus, Limnophyes, Nanocladius, Orthocladius, Paralimnophyes, Parametriocnemus, Paraphaenocladius, Paraorthocladius, Psectrocladius, Rheocricotopus, Synorthocladius, Thienemanniella, Tvetenia, Apedilum, Lithotanytarsus, Micropsectra, Paratanytarsus, Phaenopsectra, Polypedilum, Rheotanytarsus, Stempellinella, Tanytarsus*
Aquatic beetles	Dytiscidae – *Agabus, Hydroporus, Sanfilippodytes, Oreodytes*; Staphylinidae; Elmidae – *Cleptelmis, Heterlimnius*; Hydraenidae – *Hydraena vandykei*; Ptilodactylidae
Bugs	Corixidae – *Cenocorixa, Arctocorisa sutilis, Graptocorixa californica*; Saldidae
Alderflies	Sialidae – Sialis
Springtails	Collembola

In marshes, there are both aquatic and terrestrial invertebrate communities. The most abundant aquatic invertebrate families are mosquitoes (Culicidae); primitive minnow mayflies (Siphlonuridae); march flies (Bibionidae); midges (Chironomidae); predaceous diving beetles (Dytiscidae); freshwater limpet (Lancidae); water mites (Acari); slender springtails (Entomobryidae); dragonflies (Libellulidae, Lestidae); stoneflies (Chloroperlidae); true bugs (Corixidae); beetles (Hydrophilidae, Hydraenidae); caddisflies (Limnephilidae); and flies (Dixidae).

In terrestrial subalpine meadows, the most abundant invertebrate families are mites (Acari); ants (Formicidae, Tenthredinidae, Braconidae, Ichneumonidae, Mymaridae, Pteromalidae, Diapriidae, Sphecidae, Colletidae); leafhoppers (Cicadellidae, Delphacidae, Psyllidae, Aphidae); lesser dung flies (Sphaerocercidae); sheetweb and dwarf spiders (Linyphiidae); slender springtails (Entomobryidae); short-horned grasshoppers (Acrididae); bugs (Saldidae, Miridae, Nabidae, Pentatomidae, Lygaeidae); beetles (Carabidae, Staphylinidae, Scarabaeidae, Buprestidae, Throscidae, Elateridae, Phalacridae, Coccinellidae, Mordellidae, Anthicidae, Chrysomelidae, Curculionidae); butterflies and moths (Acanthopteroctetidae, Gracillaridae, Elachistidae, Coleophoridae, Gelechiidae, Pyralidae, Cambidae); flies (Ceratopogonidae, Chironomidae, Culicidae, Bibionidae, Cecidomyiidae, Mycetophylidae, Scatopsidae, Scaridae, Athericidae, Empididae, Dolichopodidae, Lonchopteridae, Phoridae, Anthomyiidae, Hippocoscidae, Muscidae, Tachinidae, Tephritidae, Sepsidae, Clusiidae, Chloropidae, Drosophilidae, Ephydridae); and spiders (Araneidae, Tetragnathidae, Agelenidae, Oxyopidae, Lycosidae, Clubionidae, Anyphaenidae, Gnaphosidae, Philodromidae, Thomisidae, Salticidae).

The most abundant aquatic montane groups are primitive minnow mayflies (Siphlonuridae); spring stoneflies (Nemouridae); black flies (Simuliidae); midges (Chironomidae); and fingernail clams (Sphaeriidae). Other aquatic groups present include mosquitoes (Culicidae); rolled-winged stone flies (Leuctridae); predaceous diving beetles (Dytiscidae); leaf beetles (Chrysomellidae); meniscus midges (Dixidae); back-swimmers (Notonectidae); northern caddisflies (Limnephilidae); pronggilled mayflies(Leptophlebiidae); crane flies (Tipulidae); springtails (Isotomidae); water mites (Acari); biting midges (Ceratopogonidae); horse flies (Tabanidae); humpless casemakers (Brachycentridae); fresh water limpets (likely Lymnaeidae); elongate-bodied springtails (Isotomidae); mayflies (Baetidae, Ephemerella, Heptageniidae, Leptophlebiidae); dragon flies (Libellulidae); stoneflies (Nemouridae, Leuctridae); bugs (Notonectidae); beetles (Scirtidae, Chrysomelidae); caddisflies (Polycentropodidae, Brachycentridae); and flies (Tipulidae, Ceratopogonidae, Tabanidae).

The most abundant terrestrial montane meadow invertebrate families are the lesser dung fly (Sphaerocercidae); Leafhoppers (Cicadellidae); pomace flies (Drosophilidae); delphacid planthoppers (Delphacidae); mites (Acari); rove beetles (Staphylinidae); and braconid wasps (Braconidae). Other terrestrial groups present include snails (Pulmonata, Basommatophora); millipedes (Spirobolida, Julida); elongate-bodied springtails (Isotomidae); bugs (Saldidae, Miridae, Nabidae, Anthrocoridae, Pentatomidae, Lygaeidae); ants - Homopterans (Delphacidae, Psyllidae, Aphidae); beetles (Carabidae, Hydrophilidae, Ptiliidae, Scarabaeidae, Buprestidae, Throscidae, Elateridae, Cantharidae, Trogossitidae, Cleridae, Sphindidae, Phalacridae, Coccinellidae, Latriidae, Mordellidae, Anthicidae, Cerambycidae, Chrysomelidae, Curculionidae); leafhoppers - Hymenopterans (Tenthredinidae, Ceraphronidae, Ichneumonidae, Mymaridae, Pteromalidae, Figitidae, Proctotrupidae, Diapriidae, Scelionidae, Platygastridae, Pompilidae, Formicidae); butterflies and moths (Acanthopteroctetidae, Coleophoridae, Pyralidae, Noctuidae); flies (Tipulidae, Psychodidae, Ceratopogonidae, Chironomidae, Culicidae, Cecidomyiidae, Mycetophylidae, Scatopsidae, Scaridae, Athericidae, Empididae, Dolichopodidae, Lonchopteridae, Pipunculidae, Phoridae, Anthomyiidae, Muscidae, Tephritidae, Sepsidae, Chloropidae, Heleomyzidae, Diastatidae, Drosophilidae, Ephydridae); and spiders (Araneidae, Tetragnathidae, Agelenidae, Pisauridae, Lycosidae, Clubionidae, Anyphaenidae, Gnaphosidae, Philodromidae, Thomisidae, Salticidae).

Nonnative Vertebrates

Fish do not naturally occur in high elevation lake basins within SEKI. However, nonnative fish were introduced to many high elevation waterbodies throughout SEKI starting in the 1860s, with stocking continuing until 1988. Surveys completed in 2002 determined that self-sustaining nonnative fish populations had become established in approximately 575 waterbodies (Knapp R., unpublished data, NPS unpublished data), plus connecting streams and marshes, and all streams that drain these sites from high to low elevations. A total of 25 of these waterbodies have been approved for fish eradication, including two completed by park researchers, and 23 completed or in-progress by SEKI. Therefore, 550 waterbodies contain nonnative fish that are candidates for fish eradication being proposed in this Restoration Plan/FEIS.

Although nonnative fish (trout) stocking was terminated in SEKI in 1988, research indicates that approximately 70% of previously-stocked lakes in SEKI have sufficient habitat to sustain trout populations in the absence of stocking (Zardus et al. 1977, Armstrong and Knapp 2004). Since trout typically live 6 to 7 years (Behnke 2002), and have been aged to 24 years in one high Sierra lake (Reimers 1979), all natural disappearances of nonnative trout in SEKI's high elevation waterbodies have likely already occurred. The remaining trout-containing waterbodies in SEKI's high elevations therefore contain self-sustaining fish populations that will continue to cause negative effects to these ecosystems unless they are eradicated by human intervention.

Many studies conducted in SEKI and elsewhere in the Sierra Nevada have studied the effects of nonnative fish introductions on native species and high elevation ecosystems (see chapter 1 and appendix C). These studies consistently documented that the widespread presence of nonnative fish has caused negative effects to native species and ecosystems. Because trout are efficient predators and competitors, they alter native food webs when they are introduced into naturally fishless habitats, including preying on large organisms such as amphibians and large-bodied aquatic insects and zooplankton, and altering, depleting or eliminating their populations. This indirectly results in less food being available to native aquatic and terrestrial predators, altering their distribution and abundance. The presence of nonnative fish in individual lakes, connecting streams and entire lake basins in SEKI continues to suppress native species and ecosystem processes, and these impacts are replicated on a landscape scale across much of the parks' high elevations.

WILD AND SCENIC RIVERS

Most of the parks' major watersheds include sections of river designated under the Wild and Scenic Rivers Act (16 USC 1271 et seq.). The goal of designating a river as wild and scenic is to preserve its free-flowing condition, water quality, and outstandingly remarkable values for the benefit and enjoyment of present and future generations. Outstandingly remarkable values may include scenic, recreational, geologic, fish and wildlife, historic, cultural or other similar values and individual segments may be designated as wild, scenic, or recreational. The classification of a river segment indicates the level of development on the shorelines, the level of development in the watershed, and the accessibility by road or trail. Wild river areas are those rivers or sections of rivers that are free of impoundments and generally inaccessible except by trail, with watersheds or shorelines essentially primitive and waters unpolluted. These represent vestiges of primitive America. Scenic river areas are those rivers or sections of rivers that are free of impoundments, with shorelines or watersheds still largely primitive and shorelines largely undeveloped, but accessible in places by roads. Recreational river areas are those rivers or sections of rivers that are readily accessible by road or railroad, that may have some development along their shorelines, and that may have undergone some impoundment or diversion in the past.

On November 3, 1987, the entire park segments of the Middle Fork and South Fork of the Kings River (54 mi) were added to the wild and scenic river system and classified as wild and the lowest 7.6 mi of the South Fork Kings River within the park was classified as recreational. The entire park segment of the North Fork of the Kern River (29 mi) was added to the wild and scenic river system and was classified as wild on November 24, 1987.

Proposed fish eradication basins that contain portions of these rivers or are watersheds feeding these rivers are Dusy, Rambaud, Barrett, Horseshoe, and Slide for the Middle Fork of the Kings River; Sixty Lake and Upper Bubbs for the South Fork of the Kings River; and Upper Kern, East Wright, Milestone, Laurel, and Crytes for the North Fork of the Kern River. None of the proposed restoration sites are within the designated segments of these rivers. Therefore, none of the restoration activities would occur within or affect the designated segments of any wild and scenic rivers. All of the sites proposed for piscicide use, except one, are far from designated wild and scenic rivers or river segments. One site proposed for piscicide treatment is near the headwaters of the North Fork of the Kern River, with the downstream edge of the treatment area approximately 650 ft from the designated wild and scenic river. Because one alternative proposes to alter a tributary of a wild and scenic river by blasting barriers (if needed), a section 7(a) determination has been prepared to evaluate the potential of the actions described in the Restoration Plan/FEIS to either invade or diminish the scenic, recreational, fish, or wildlife values of the wild and scenic river (appendix K).

WATER QUALITY

The water quality found in the Sierra Nevada is considered some of the highest in the state. Five major rivers originate partly or entirely in SEKI: Kaweah, Kern, Kings, San Joaquin and Tule. Water in all five watersheds within SEKI is of excellent quality, with water in the Kaweah, Kings and Kern, and San Joaquin Rivers consistently testing above state and federal standards (NPS 1997). (The portion of the Tule River that occurs in SEKI is small and remote and thus not regularly sampled.) The State of California considers the surface water quality of these rivers to be beneficial for wildlife and as freshwater habitat, contact and non-contact recreation, freshwater replenishment, and municipal and domestic water supply as indicated in the California Regional Water Quality Control Board (Central Valley Region) *Water Quality Control Plan for the Tulare Lake Basin, Second Edition* (CRWQCB 2015A) and *Water Quality Control Plan (Basin Plan) for the Sacramento River Basin and the San Joaquin River Basin, Fourth Edition* (CRWQCB 2015B). Sixty percent of California's water originates from small streams in the Sierra Nevada (Hunsaker and Eagan 2003). Water within the parks is clear and generally contains extremely low concentrations of dissolved solids and naturally low levels of dissolved nutrients.

Precipitation comes primarily in the form of snow in the winter snowpack. Variation in seasonal snowmelt is the primary driver affecting physical characteristics of aquatic systems in project areas (NPS 2005). The amount of water stored as snowpack increases through mid-April at higher elevations. Melting typically begins in March or April and continues through May or June. In order to understand the timing and volume of runoff, a good understanding of the spatial variation of snowpack properties is needed. The factors contributing to variation in snow water equivalent (slope, aspect, elevation, vegetation type, surface roughness, energy exchange) are exaggerated in alpine areas found in the project area, resulting in a heterogeneous snowpack that change markedly in space and time. Hydrology in a typical high elevation watershed can be divided into three periods: snowpack runoff, a transition period in summer as snowpack runoff decreases and little precipitation occurs, and a low-flow period from late summer through winter (Williams et al. 1993).

Nearly all of SEKI's approximately 3,500 lakes, ponds, and marshes are located at high elevations (above 8,000 ft (2,400 m) (Knapp R., unpublished data). The majority of these waterbodies – approximately 2,500 – are ponds (< 2.5 ac/1 ha), many of which are very small, only holding snowmelt water during early summer and drying completely during late summer (~1,000 are < 0.25 ac/0.1 ha).Approximately 1,000 waterbodies are lakes (2.5 ac/1 ha or larger), all of which currently hold water year-round. In addition, many of the lakes are large (~600 are 5 ac/2 ha or larger). They vary in depth from less than 1 ft (0.3 m) to over 100 ft (30.5 m) (Knapp R., unpublished data). There is an estimated 2,144 mi (3,450 km) of mapped rivers and streams in SEKI (NPS 2005). There also is an unknown additional amount of unmapped, primarily intermittent streams (NPS 2005). The largest streams produce peak flows around 2,900 cubic feet per second (cfs), and these flows drop to about 50 to 90 cfs during August (NPS 1999).

Most of the alpine/subalpine waters could be described as cold, clear and having very low ionic potential. Water temperatures range from freezing up to about 59°F (15°C), although very shallow water with good solar exposure may range up to around 68°F (20°C). Water turbidity for lakes and streams is usually below 0.2 Nephelometric Turbidity Units (NTU), but this may double or triple in ponds and wet meadows. In granitic areas, specific conductance is often below 10 microsiemens per centimeter (µS/cm) in lakes and ponds, but may exceed 40 µS/cm in streams, meadows or metamorphic areas. Lakes and streams are typically saturated with oxygen (>8 milligrams per liter (mg/l)), but wet meadows sometimes have less oxygen, which may be due to the presence of organic soils and decomposing vegetation.

On average, the pH of alpine and subalpine waters is slightly acidic, but varies from slightly alkaline to acidic. These waters are poorly buffered and acid neutralizing capacity is usually below 0.1 milliequivalents per liter (meq/l). Compared to alpine and subalpine waters, the water in montane streams tends to be slightly warmer and have higher concentrations of dissolved constituents. Where the parks' waters originate or pass through metamorphic rocks, the bedrock has a greater influence on water chemistry than in granitic areas. This is especially true for marble, which can cause specific conductance to be well over 100 µS/cm. Mineral springs also exert extensive influence on water chemistry downstream. These sites are very rich in dissolved solids, especially iron, and the influence may be noticeable for several miles downstream. The rarest water features are thermal springs, and none are known within the project area, as none were detected in the 1997 to 2002 lakes survey (Knapp R., unpublished data).

The concentrations of major cations, anions, and other dissolved constituents are very dilute in high elevation surface waters of SEKI. As a group, high Sierran lakes and streams are extremely base-poor and classically “acid sensitive” (Stoddard 1995). The great potential for acidification of Sierran lakes is confirmed by the very low alkalinity of these waters (0 to 8 mg/l as $CaCO_3$), producing a weak buffering capacity (Tonnessen and Harte 1982). Alpine lakes and streams also have conductivity readings below 20 µS/cm. The ionic potential typically increases as you drop in elevation, where conductivities may exceed 100 µS/cm by the time the rivers reach the parks’ boundary (NPS 1999). This is partially due to the influence from marble, schist, and other metamorphic rocks along the western side of the park and also high productivity in low elevation watersheds which contribute more suspended particles and nutrients into aquatic systems. Waters are typically very clear with turbidities generally well under 0.5 (NTU), though meadow water may exceed 1.0 NTU. Nutrients like phosphate or nitrate concentrations are generally less than 40 micrograms per liter (µg/l) and ammonia is generally undetectable. Except for mineral springs, thermal springs, and some wet meadows, the water is normally saturated with oxygen (6.8 to 8.8 mg/l). Typical pH concentrations are slightly acidic, but can vary from about 5.5 to 8.5, with some sites exceeding this range (NPS 2005).

On a regional scale, anthropogenic (human related) impacts to water chemistry are pervasive due to deposition of pesticides, nutrients, acidic deposition, commercial organic compounds, and other airborne substances (Melack et al. 1989, Zabik and Seiber 1993, Stoddard 1995, McConnell et al. 1998, Datta et al. 1998, LeNoir et al. 1999, Sickman et al. 2003). Air pollution is considered a significant threat to natural resources of the Sierra Nevada, including wildlife (Landers et al. 2008). Current evidence suggests that one of the biggest threats to the parks’ water quality is air pollution. Air pollution adds acidic deposition, nutrients and other contaminants to the parks’ waters. Originating in granite, Sierra waters are naturally low in nutrients. There is some evidence that the addition of airborne nitrates and ammonia is causing nutrient enrichment is Sierra waters, increasing the levels of nutrients naturally found in aquatic systems (Sickman et al. 2003). The drift of pesticides and other contaminants from upwind agricultural areas is one of the most serious concerns. Measurable amounts of pesticides fall on the parks, and pesticide residues have been found in the tissues of aquatic fauna (Sparling et al. 2001, Landers et al. 2008, Bradford et al. 2011, Meyer et al. 2013).

Levels of fecal bacteria are generally low, though natural sources often contribute high concentrations of fecal bacteria during runoff events (NPS 1983, Clow et al. 2013). This is most likely due to wildlife that lives within the watershed. While fecal bacteria contributions from visitors are not well known, Clow et al. (2013) found the lowest frequency of fecal bacteria in areas with the least human use.

Recreational activities such as horseback riding, swimming and hiking can lead to the introduction of organic, physical, and chemical pollutants into aquatic systems. Water quality in the parks may be affected by human and animal waste, with the potential to contain parasites such as *Giardia lamblia* and *Cryptosporidium.* The presence of low levels of coliform bacteria in many park waters indicates that the overall watershed risk for harboring microbes capable of causing human disease is generally low (NPS 1997). Packstock (horses, mules, burros and llamas) and people are among the potential sources of coliform in surface water.

NATURAL SOUNDSCAPES

Natural soundscapes are an intrinsic element of both the parks and the wilderness environment. Soundscapes include all the natural sounds that are inherent in nature, such as singing birds, insect noises, the call of frogs, and the trickle of a creek, as well as natural quiet. The soundscape also includes anthropogenic sounds produced by aircraft, people conversing, and machinery.

Within the alpine zone, the natural soundscape is dominated by wind noise since there are very few trees at this elevation. In the upper montane and subalpine zones, the natural soundscape is less dominated by wind than in the alpine zone, due to the presence of trees and tall shrubs that block and reduce wind speed. The dominant tree species in the subalpine coniferous forest acoustical zone is lodgepole pine, which grows with foxtail pine in some of the sites under consideration and with whitebark pine or red fir in other areas. Where they occur, willow and aspen play a large role in attenuating distant sounds. Compared to the alpine zone, animal sounds are more frequently audible. A greater diversity of birds, insects, and mammals occupy this forest zone. Audible sounds are usually generated by nearby natural sources rather than carried from distances. Woodland birds such as thrushes and warblers can be heard in many areas. Flowing water developing into larger streams influences the nearby soundscape, and dominates the acoustics in the riparian and surrounding areas.

Human-generated sounds are most common in travel corridors near trails and campsites. Aircraft, both military and civilian, can be heard overhead throughout this zone and are a source of sound pollution. In addition, the crest of the Sierra is subject to an atmospheric phenomenon called Barisal Guns (mistpouffers). On certain days, loud booms can be heard along the crest of the Sierra. The origin of these booms have been disputed, but they could occur when upper atmosphere conditions propagate sound waves from explosions which occur up to 100 mi (160 km) away, such as at military bombing ranges, though sources can also be distant thunder.

WILDERNESS

Sequoia and Kings Canyon National Parks' total designated wilderness is 808,078 ac (327,018 ha) — approximately 93.3% of the parks' total acreage of 865,964 ac (350,443 ha). In addition, there is an area of approximately 29,516 ac (11,945 ha) of proposed wilderness that is managed as wilderness in accordance with NPS policy. Sequoia and Kings Canyon National Parks' original wilderness designation occurred under the *California Wilderness Act of 1984* (PL 98-425, 98 Stat. 1619); additional acreage was designated as wilderness by the *Omnibus Public Land Management Act of 2009*. Nearly the entire project area is within designated wilderness, with only a small portion located outside wilderness.

Section 2(c) of the Wilderness Act of 1964 defines wilderness as:

> A wilderness, in contrast with those areas where man and his own works dominate the landscape, is hereby recognized as an area where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain. An area of wilderness is further defined to mean in this Act an area of undeveloped federal land retaining its primeval character and influence, without permanent improvements or human habitation, which is protected and managed so as to preserve its natural conditions and which (1) generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable; (2) has outstanding opportunities for solitude or a primitive and unconfined type of recreation; (3) has at least five thousand acres of land or is of sufficient size as to make practicable its preservation and use in an unimpaired condition; and (4) may also contain ecological, geological, or other features of scientific, educational, scenic, or historical value.

Agencies managing wilderness are required by law to preserve its wilderness character. Wilderness character is considered to have five general qualities: untrammeled, undeveloped, natural and primeval character, and outstanding opportunities for solitude or a primitive and unconfined type of recreational experience, and other features of value.

The NPS applies the minimum requirement concept to all administrative activities that affect the wilderness character. The application of the minimum requirement concept is intended to minimize impacts on wilderness character and must guide all management actions in wilderness. A project minimum requirement analysis is included as appendix A.

HEALTH AND SAFETY

The health and safety of NPS staff is guided by NPS Director's Order #50B: *Occupational Safety and Health Program* (NPS 2008C); and the health and safety of NPS visitors is guided by NPS Director's Order #50C: *Public Risk Management Program* (NPS 2010B).

NPS Staff Safety
NPS Director's Order #50B: *Occupational Safety and Health Program* provides "NPS managers, supervisors, and employees with direction for the implementation of a comprehensive risk management program throughout the NPS. Specific program objectives are to establish and implement a continuously improving and measurable risk management process that (1) provides for the occupational safety and health of NPS employees; (2) establishes effective site specific occupational safety and health programs at all NPS units; (3) requires other employers operating in NPS units to provide for the occupational safety and health of their employees; (4) identifies strategies to minimize the loss of NPS human, physical, and fiscal resources due to preventable accidents; and (5) coordinates risk management and workers' compensation program management to achieve these objectives."

The wilderness of these parks includes large areas with steep terrain, swift rivers, extreme weather, and high elevations. Safety hazard exposure for NPS field staff include lightning, unexpected snow storms, dehydration, hypothermia, heat-related illnesses, exhaustion, altitude sickness, hiking related injuries, exposure to cliffs and cross-country route finding, insect stings and bites, gill netting, electrofishing, and piscicide contact.

Visitor Safety
NPS Director's Order #50C: *Public Risk Management Program* states that "it is the intent of the NPS that all visitors have an injury-free park experience. However, each year, thousands of visitors to national parks are involved in preventable incidents that result in serious injuries or fatalities. Because of the wide range of activities visitors engage in, the diverse type, origin, and experience level of park visitors, and the inherent risks that cannot be managed or transferred away, visitor risk management in the national parks continues to be a difficult challenge. The NPS's mission is to conserve park natural and cultural resources and processes unimpaired, and provide opportunities for the public to enjoy them. In doing so, the NPS must strive to prevent visitor injuries and fatalities within the limits of available resources. Within this context, visitor risk management does not mean eliminating all dangers, nor can the NPS guarantee visitor safety or be responsible for acts and decisions made by visitors that may result in their injury or illness."

Visitor use would occur in the proposed project area with a range of use levels depending on the location. The majority of proposed fish eradication areas are located in remote areas that would have low visitor use. Some areas would have moderate visitor use, such as Sixty Lake and Dusy Basins. One area – Crescent Basin – is relatively close to frontcountry areas so it has the potential to have higher visitor use. Visitor use in the project area could include day hiking, backpacking, overnight camping, recreational fishing, rock climbing, nature study, photography horseback riding/packstock trips, swimming/wading, and/or similar activities.

VISITOR EXPERIENCE AND RECREATIONAL OPPORTUNITIES

In 2015, visitation at SEKI was approximately 1.57 million people (NPS 2015D). Visitation is seasonal with most visits occurring in the summer months. July and August are typically the most popular months. The developed areas that have NPS and/or concessioner-operated visitor facilities (about 2.5% of the parks) receive around 98% of the use; wilderness areas receive about 2% of the use (NPS 2007).

The project areas are located nearly entirely within wilderness, and include high elevation lakes, streams, and meadows which are destinations for wilderness users. The Sequoia and Kings Canyon wilderness areas offer opportunities to experience a variety of activities away from the busy pace and noise of automobiles and modern technology. Activities range from sightseeing and picnics to multiple-night backpacking or packstock trips. Visitors can enjoy the solitude of nature, the sounds of water and wind, and the natural scenery. Recreational opportunities include photography, nature study, hiking, backpacking, horseback riding/pack trips, swimming/wading, recreational fishing, camping, rock climbing, winter activities, and other similar activities.

Proposed fish eradication basins associated with the action alternatives that are located within approximately one-quarter mile of maintained trails include Upper Evolution, Dusy, Upper Bubbs, and Crescent Basins. Barrett, Milestone, Blossom, and Tablelands are more than one-quarter mile away from a maintained trail.

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CHAPTER 4 - ENVIRONMENTAL CONSEQUENCES

This section contains the environmental impacts, including direct and indirect effects, and their significance to the alternatives. Impacts are evaluated based on context, intensity and duration, and on whether they are direct, indirect, or cumulative impacts. This analysis is based on the assumption that the mitigation measures identified in the "Mitigation Measures Common to All Alternatives" section of this Restoration Plan/FEIS would be implemented for the action. Mitigations are actions taken to lessen the severity and probability of a potential impact.

METHODOLOGY

Overall, the NPS based these impact analyses and conclusions on a review of existing peer-reviewed literature and park studies, unpublished reports and data, information provided by experts within the park and other agencies and institutions, professional judgment and staff expertise and insights, and public input. These analyses relied most heavily on existing literature, derived from the research that has been done on MYLF and the ecosystems they inhabit within and outside of SEKI. The following is a description of several terms used within "Chapter 4 - Environmental Consequences" to assess the impacts of each alternative on each impact topic.

Type: Impacts can be beneficial or adverse. For example, restoring populations of native species to a healthier condition would be a beneficial impact, while introducing human-derived noise to a wilderness site would be an adverse impact.

Context: Context is the setting within which an impact would occur, such as local, parkswide, or regional.

Impact intensity: Impact intensity is defined individually for each impact topic. There may be no impact, or impacts may be negligible, minor, moderate, or major. A table of impact intensity definitions for each impact topic is included within each impact topic description.

Duration: Duration of impact is defined independently for each resource because impact duration is dependent on the resource being analyzed. Depending on the resource, impacts may be short term (last for the duration of the project), or long-term (for a single year or season, or longer).

Direct and indirect impacts: Direct effects are caused by an action and occur at the same time and place as the action. An example of a direct effect would be the immediate response to treatment actions such as fish being eradicated by use of gill nets. Indirect effects are caused by the action and occur later or farther away, but are still reasonably foreseeable. An example of an indirect effect would be increased population size of mayflies because of nonnative fish having been removed. Direct and indirect impacts are considered in this analysis.

This analysis can only address threats based on professional knowledge and the best available science. This analysis cannot address the effect of new threats, such as the introduction of new invasive species or pathogens. This analysis can only speculate on the effects of global warming with current information, and even the relationship between amphibian chytrid fungus and MYLFs is not adequately known to project specific outcomes to specific treatments. In these situations, a variety of potential outcomes will be considered.

CUMULATIVE EFFECTS

Cumulative effects are defined as “the impact on the environment which results from the incremental impact of the action when added to other past, present and reasonably foreseeable future actions, regardless of what agency (federal or nonfederal) or person undertakes such other actions” (40 CFR 1508.7). Cumulative effects can result from individually minor, but collectively significant, actions taking place over a period of time. The CEQ regulations that implement NEPA require assessment of cumulative effects in the decision-making process for federal projects. Cumulative effects are considered for all alternatives and are presented at the end of each impact topic discussion.

Methods for Assessing Cumulative Effects
To determine potential cumulative effects, past, present, and foreseeable future actions and land uses were identified in or near the project area. Potential future actions were determined by reviewing plans and activities in SEKI, YOSE, Inyo NF, Sequoia NF, and Sierra NF. Since the majority of the project area and areas of effect are well within designated wilderness, there are few ongoing or planned actions for future projects. Identified actions include ecosystem restoration projects and projects that involve ongoing and reoccurring flights over park wilderness. Existing and anticipated visitor use trends were also analyzed. These actions were then assessed in conjunction with the impacts of the alternatives to determine if they would have any added adverse or beneficial effects on a particular natural resource, park operation or visitor use. The evaluation of cumulative effects was based on the available information about the actions.

Impact topics will have differing areas of effect depending on the resource being analyzed. For examples, impacts to natural soundscapes have an area that is generally limited to SEKI, while impacts to MYLFs have an area of effect that ranges from Sequoia NF in the south to YOSE in the north. This area was chosen for the analysis because this section of the MYLF range has relatively similar habitat. North of Stanislaus National Forest the habitat changes (e.g. lower elevations and fewer lakes and more stream habitat).

Projects that Make Up the Cumulative Effects Scenario
To determine potential cumulative effects, projects within the range of MYLFs in SEKI, YOSE, Inyo NF, Sequoia NF, and Sierra NF were reviewed. Potential projects identified as cumulative actions included any past projects that currently affect the same resources as the alternatives, and projects that are currently being implemented or that would be implemented in the reasonably foreseeable future that could impact the same resources as any of the alternatives. These actions are evaluated in the cumulative effects analysis in conjunction with the impacts of each alternative to determine if they would have any additive effects on a particular resource, including natural and cultural resources, the wilderness environment and visitor use. Because some of the future activities are in the early planning stages, the evaluation of some cumulative effects is based on preliminary descriptions of those projects.

Past, Current, and Future Actions
Past Nonnative Fish Stocking Actions
From 1870 to 1988, one or more species of nonnative trout, including golden, rainbow, golden x rainbow hybrid, brook, and brown trout, were introduced into many heretofore fishless waterbodies throughout SEKI (Christenson 1977, Knapp 1996). While stocking no longer occurs within SEKI, Surveys conducted from 1997 to 2002 determined that self-sustaining nonnative trout populations had become established in 575 lakes, ponds, and marshes (Knapp R., unpublished data), plus connecting streams, and nearly all streams that drain these sites from high to low elevations. 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. This has resulted in long-term adverse effects on the natural quality of wilderness, MYLFs, vertebrates and invertebrate populations throughout the parks, and on adjacent USFS lands.

General Resource Management and Science Activities
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. These projects may adversely affect the qualities of wilderness character, including the untrammeled, undeveloped, and opportunities for solitude, and may result in beneficial effects on the natural quality of wilderness.

Current/Ongoing and Planned High Elevation Ecosystem Restoration and Research
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, Yosemite toad, golden trout (including the Little Kern golden trout and 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. The following section provides a summary of the activities associated with each program.

<u>Mountain Yellow-legged Frogs</u>
The NPS in YOSE and SEKI, the U.S. Forest Service (USFS), and the California Department of Fish and Wildlife (CDFW) have on-going habitat restoration programs that include fish eradication. Thus far, SEKI has restored 15 lakes and is nearly finished restoring 10 lakes by eradicating nonnative trout (Vredenburg 2004, NPS 2012A; the USFS has restored or is in the process of restoring 7 lakes by eradicating nonnative trout (CDFW 2011); CDFW has restored or is in the process of restoring 48 lakes by removing nonnative trout (CDFW 2011); and YOSE has restored or is in the process of restoring 8 lakes (CDFW 2011). Restoration efforts have been shown to successfully reverse the negative effects of introduced trout on Sierra Nevada mountain yellow-legged frog populations (Vredenburg 2004, Knapp et al. 2007, NPS 2011A).

Helicopters and/or packstock are typically needed to mobilize and demobilize these operations each summer, depending on the project specific determinations in the wilderness minimum requirement analysis.

Intensive field studies on MYLFs have also occurred in SEKI, YOSE, Inyo NF, and Sierra NF, including efforts to better understand the effects of nonnative fish, amphibian 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. Helicopters have been used to help perform some of these actions, primarily those in which short transportation times were required to ensure animal survival.

The NPS in YOSE and SEKI, and the CDFW on adjacent USFS administered lands have conducted experimental reintroductions independently, and/or in collaboration with academic and USGS scientists. Receiving waters included sites that were previously stocked but had reverted back to fishless condition once stocking was discontinued, sites where stocking had never occurred, and sites where fish eradication efforts preceded reintroductions. All life stages (egg masses, tadpoles, juveniles, and adults) have been used in reintroductions. The amphibian chytrid fungus infection status of individuals from source populations and the history of amphibian chytrid fungus at the receiving site have varied. These efforts, summarized in CDFW 2011, have had mixed levels of success. Attempts to reestablish several MYLF populations that recently went extinct have occurred in SEKI and YOSE. Approximately nine MYLF reintroductions were recently conducted by reintroducing animals from other existing populations. Helicopters were used to help perform those actions in which short transportation times were required to ensure animal survival.

The FWS, USFS, NPS, CDFW, and academic and agency scientists collaborated to develop the MYLF Conservation Assessment (Brown et al. 2014) and are collaborating to develop a MYLF Conservation Strategy (FWS *in preparation*). The conservation assessment describes the current condition of MYLFs in the Sierra Nevada, and threats that could affect their condition. The conservation strategy will describe recommended actions to ensure that viable, self-sustaining populations of MYLFs persist into the future, with metapopulations well-distributed throughout their historic range by maintaining both genetic and ecological diversity.

When considered together, these activities may result in adverse effects on the qualities of wilderness character, including the untrammeled and undeveloped qualities from the manipulation of MYLFs and the use of helicopters, and opportunities for solitude from the presence of crews and the sight and sound of helicopters. These actions require a permit from the USFWS and may result in an adverse or beneficial impact on MYLFs.

<u>Yosemite Toad</u>
Past activities involving the Yosemite toad include long-term monitoring by academics, the USGS, and the USFS, and a livestock grazing study conducted by USFS. Currently there are several studies occurring in the range of the Yosemite toad. Projects occurring in YOSE and SEKI involve: (1) documenting current distribution; (2) relating Yosemite toad population trends to ongoing visitor uses of toad meadow habitat; (3) relating habitat suitability/condition to toad distributions and historic visitor pack stock use patterns; (4) providing detailed, credible information for analysis and management recommendations for the SEKI Wilderness Stewardship Plan ; and (5) developing best management practices for traditional wilderness visitor use activities to protect toad habitat and preserve visitor opportunities. These studies are observational and not likely to have an effect on the Yosemite toad, other than increasing knowledge about the species. There is also a study in YOSE and SEKI that is integrating information on Yosemite toad population connectivity (gained through genetic analyses) with data on both recreation use and climatic variability to better understand how these stressors influence Yosemite toad population distribution. Tail-clips were collected from Yosemite toad tadpoles for the genetic analysis. In addition, there is a study assessing the effects of amphibian chytrid fungus on toads that involves collecting skin swabs from individual animals on NPS and USFS lands. These activities may result in adverse effects on the qualities of wilderness character, including the untrammeled quality due to the manipulation of the Yosemite toad, and opportunities for solitude due to the presence of crews in wilderness. These actions require a permit from the USFWS and may result in an adverse or beneficial impact on Yosemite toads.

<u>Golden Trout Complex and Kern River Rainbow Trout</u>
The CDFW, USFS, FWS, and SEKI are cooperating to recover Little Kern golden trout (federally threatened), California golden trout, and Kern Rainbow trout within their historic ranges. A CDFW revised fishery management plan serves as a recovery plan for Little Kern golden trout (Christenson

1984), a conservation assessment and strategy guides the conservation of California golden trout (CDFW 2004), and the Upper Kern Basin Fishery Management Plan guides management of fish and other native resources in the upper Kern watershed (Stephens et al. 1995).

There is a long history of golden trout restoration efforts in the Sierra Nevada (CDFW 2004). Efforts to reverse the decline of Little Kern golden trout and California golden trout include habitat improvement via eradication of nonnative fish that have the capacity to hybridize with native stocks; restocking with pure fish; restoring damaged critical habitat; and protecting native stocks from habitat deterioration and excessive angler harvest. Genetically pure populations within the native range of both of these fishes are rare, and generally limited to select headwater areas of a few tributaries of the Kern River (Stephens 2007). Efforts to eradicate hybrid fish and replace with pure fish thus appear to have achieved limited success. Packstock are sometimes needed to mobilize and demobilize these operations, particularly when heavy or bulky equipment or supplies are needed. In addition, piscicides have been used to eradicate certain populations of hybrid fish.

There was one past project that used piscicides within the parks. In 1979, antimycin A was used to successfully eradicate nonnative brook trout from Hidden Lake and connected stream reaches, and rotenone was used to treat a section of Soda Spring Creek from within Sequoia National Park and downstream to the park boundary (Christenson 1984). This action was park-approved for implementation by CDFW to contribute to recovery of federally threatened Little Kern golden trout. However, the impacts from this action ended long ago, and thus there are no additive effects on vertebrates from this action. There are no other past, ongoing, or future planned project activities within the parks that used or propose the use of piscicides. Herbicide use occurs within the parks as part of a weed management program, but no projects are planned in or adjacent to treatment areas in the foreseeable future that would utilize herbicides.

Efforts to reverse the decline of Little Kern golden trout and California golden trout within their native ranges outside the parks include habitat improvement via eradication of nonnative fish that have the capacity to hybridize and compete with native stocks; restocking with pure fish; restoring damaged critical habitat; and protecting native stocks from habitat deterioration and excessive angler harvest. Piscicides were used outside the parks in the area of cumulative effect several times between 1976 and 1994 to eradicate certain populations of hybrid and competitor fish for California golden trout restoration in the South Fork Kern River (Pister 2008) and Little Kern golden trout restoration in the Little Kern River (Christenson 1984). However, the impacts from these actions ended long ago, and thus there are no additive effects on vertebrates from these actions. There are no other past, ongoing, or future planned project activities outside the parks in the area of cumulative effect that used or propose the use of piscicides.

Genetically pure populations within the native range of Kern River rainbow trout appear to have disappeared (Erickson et al. 2010), although a few populations transplanted outside of their native range to historically fishless waters in isolated headwater areas appear to have high genetic purity. These populations may have value for conservation of Kern River rainbow trout within their native range and may be utilized in the future for restoration and/or recreational enhancement.

When considered together, these activities may result in adverse effects on the qualities of wilderness character, including the untrammeled and undeveloped qualities from the manipulation of native fish, and the use of helicopters, and opportunities for solitude from the presence of crews and the sight and sound of helicopters. These actions require a permit from the USFWS and may result in an adverse or beneficial impact on golden trout.

Bighorn Sheep

The CDFW, USFS, FWS, and SEKI cooperate to conserve the federally endangered Sierra Nevada bighorn sheep, guided by a recovery plan (FWS 2007B) and designation of critical habitat (FWS 2008A). Actions conducted in recent decades include intensive field studies and monitoring, reestablishment of three additional populations in historic habitat, and creation of an interagency advisory group.

The 5-Year Review: Summary and Evaluation (FWS 2008C) describes what steps have been taken to promote the recovery of the bighorn sheep. For the next 10 years, CDFW, Inyo NF and NPS expect to implement or facilitate continued research and recovery programs in the Sierra Nevada as listed in the recovery plan, including locations within the project and cumulative effects areas of this Restoration Plan/FEIS. SEKI recently approved (August 2011) research and recovery actions that include the use of helicopters to capture and collar bighorn sheep for the purpose of conducting monitoring and translocating captured individuals to establish additional populations in designated critical habitat that is currently unoccupied (NPS 2011B). Inyo NF is currently considering similar actions.

When considered together, these activities may result in adverse effects on the qualities of wilderness character, including the untrammeled and undeveloped qualities from the manipulation of bighorn sheep populations, and the use of helicopters, and opportunities for solitude from the presence of crews and the sight and sound of helicopters. These actions require a permit from the USFWS and may result in an adverse or beneficial impact on Sierra Nevada bighorn sheep.

Maintenance Activities

There are more than 800 mi (1,287 km) of trail 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 rare occasions, 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. When considered together, these activities may result in adverse effects on the qualities of wilderness character, including the untrammeled and undeveloped qualities from restoration projects and the use of helicopters, and opportunities for solitude from the presence of crews and the sight and sound of helicopters. The actions would have beneficial effects on the natural quality of wilderness from preserving trail features and restoring areas impacted by social trailing, and could result in adverse effects on the natural quality from the removal of hazard trees and the use of stock.

Other Projects in Wilderness

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. When considered together, these activities may result in adverse effects on the qualities of wilderness character, including the undeveloped qualities from the use of helicopters, and opportunities for solitude from the presence of crews and the sight and sound of helicopters.

SPECIAL-STATUS SPECIES

Methodology for Analyzing Impacts
Section 7 of the Endangered Species Act mandates all federal agencies to determine how to use their existing authorities to further the purposes of the Act to aid in recovering listed species, and to address existing and potential conservation issues. Section 7(a)(2) states that each federal agency shall, in consultation with the Secretary of the Interior, ensure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of designated critical habitat. NPS *Management Policies* 2006 (NPS 2006A) state that potential effects of NPS actions would also be considered for state- or locally listed species. For this plan, special-status species include species that are federally or state-listed, proposed, or candidates for listing, and other species of concern within the project area that are rare or otherwise merit special consideration (appendix F). The criteria for evaluating the impacts of the alternatives on special status species (Table 21) applies to those special status species that occur within the project area and which may be affected by implementation of this plan. Five special status species, including both species of MYLFs, Yosemite toad, Little Kern golden trout, and Sierra Nevada bighorn sheep (and its critical habitat) have the potential to be affected by project actions. The area of cumulative effect for this impact topic includes high elevation lands within SEKI, YOSE, Inyo NF, Sequoia NF and Sierra NF. The NPS made the determination of effects of the alternatives to special-status species following guidance outlined in the 1998 FWS and National Marine Fisheries Service *Endangered Species Act Consultation Handbook: Procedures for Conducting Section 7 Consultations and Conference*.

Table 21. Special-Status Species Impact and Intensity Descriptions

Impact Intensity	Intensity Description
No effect	The effects of the proposed action and its interrelated and interdependent actions would not directly or indirectly affect special-status species or destroy/adversely modify designated or proposed critical habitat.
May affect, not likely to adversely affect	The effects of the proposed action and its interrelated and interdependent actions to special-status species or designated critical or proposed habitat are expected to be beneficial, discountable, or insignificant. Beneficial effects are contemporaneous positive effects without any adverse effects to the species or habitat. Insignificant effects relate to the size of the impact (and should never reach the scale where take occurs), while discountable effects are those that are extremely unlikely to occur. Based on best judgment, a person would not: (1) be able to meaningfully measure, detect, or evaluate insignificant effects; or (2) expect discountable effects to occur.
May affect, likely to adversely affect	The effects of the proposed action and its interrelated and interdependent actions to special-status species or designated critical or proposed habitat are expected to be adverse. In the event that the overall effect of the proposed action is beneficial to the listed species or critical habitat, but may also cause some adverse effect on individuals of the listed species or segments of the critical habitat, then the determination "is likely to adversely affect."

Short-term—impacts occur during project activities.

Long-term—impacts continue after project activities are completed.

Impacts of Alternative A: No Action on Special-Status Species
Under this alternative, nonnative fish removal would be limited to 25 treatment lakes and ponds and 3.7 mi (6.0 km) of connected stream habitat contained in seven basins (see Table 6 and Figure 5), all of which were previously approved for treatment (NPS 2001, 2009A). Nonnative fish are currently being removed using physical methods only, including gill netting and electrofishing. Self-sustaining nonnative trout populations would remain in 550 lakes, ponds, and marshes known to contain nonnative fish, plus hundreds of miles of connected stream habitat.

Mountain Yellow-legged Frogs
Extensive research has shown that nonnative trout have adverse effects on MYLFs, primarily due to predation, competition and population fragmentation (see chapter 1). Removing nonnative trout reverses these effects and allows MYLF populations in treatment areas to expand (Knapp et al. 2007, NPS 2012A). Completing the removal of nonnative fish from the 25 treatment waterbodies and 3.7 mi (6.0 km) of streams included in this alternative would therefore provide long-term beneficial effects on MYLFs in those locations. These waterbodies comprise 4% of the parks' 575 high elevation waterbodies known to contain nonnative fish at the beginning of the treatment period.

In treated areas with extant MYLF populations, individuals sometimes get caught in gill nets. Depending on the length of time they have been caught before staff find and release them, individuals can be killed, released with visible injury, or released with no visible injury. In SEKI from 2001 to 2013, a total of 205 MYLFs were captured in gill nets, including 145 that died (84 frogs, 61 tadpoles), 22 that were released injured, and 38 that were released with no visible injury (NPS 2015A). These 205 MYLF captures represent 0.5% of all gill net captures (40,606 nonnative fish + 205 MYLFs + 94 other non-target animals). Total gill net effort was 8,313,701 net hours during 17,161 different set-and-pull events. Therefore, the 205 MYLF captures represent a capture rate of 2.5 individuals for every 100,000 hours gill-netting; and the 145 MYLF mortalities represent a mortality rate of 1.7 individuals for every 100,000 hours of gill-netting.

In treated areas with extant MYLF populations, individuals sometimes get stunned by electrofishing. Individuals typically hop or swim away as soon as the electrofishing field is stopped; rarely individuals need from several seconds to 2 minutes to recover before moving away from the work area. From 2001 to 2013, a total of 497 hours of electrofishing in SEKI resulted in zero observed MYLF mortalities (NPS 2015A).

Some MYLF individuals present in treated areas and not captured by gill nets or caught in electrofishing fields would exhibit a flight response during treatment activities, but the flight response would be no different than what would occur when visitors walk by these areas. These disturbances would be temporary in nature, and any individuals that took flight would typically resume their prior behaviors within a short amount of time.

Although eradicating nonnative fish using gill nets and electrofishers has had an adverse effect on a small percentage of individual MYLFs, these treatments have had a substantial beneficial effect on the species as a whole. Removal of nonnative fish resulted in a very large overall increase of MYLF populations in the treatment areas (NPS 2012A). From 2001 to 2011, SEKI eradicated fish from 10 lakes and nearly eradicated fish from 3 lakes. In nine of these lakes, in which MYLFs remained disease free 3 years after fish removal, average density (tadpoles + frogs) increased by 13-fold (from 1.6 to 21.1 per 10 m /32 ft of shoreline); one lake showed a 49-fold increase (from 0.9 to 43.9 per 10 m /32 ft of shoreline). Several of these restored populations are now among the largest in the entire range of MYLFs. In addition, typically no or few incidental captures of MYLFs occur during the first year of fish removal, however, as native wildlife increasingly migrates into waterbodies when eradication is further along, incidental captures appear to increase. The CDFW has had similar results from restoration efforts adjacent to disease-free sites (CDFW 2011).

The question remains as to whether fish eradication efforts would result in population growth or natural recolonization from much smaller populations infected with amphibian chytrid fungus. In 2002, the USGS began a fish eradication effort from a site containing one of the last MYLF populations in southern California. This population was down to 5 to 15 individuals. Fish eradication was completed at this site in 2010, and the population has increased to over 50 individuals and is now the largest remaining population in southern California (USGS unpublished data). In YOSE, MYLFs have been observed at five of the nine fish eradication sites, even though amphibian chytrid fungus is present throughout YOSE. In SEKI, infected MYLFs have been observed in eight fish eradication lakes.

Overall, this alternative is expected to result in the following effects on MYLFs:

- *may affect, likely to adversely affect* MYLFs in 25 treated waterbodies and 3.7 mi (6.0 km) of streams contained in seven basins due to the potential for disturbance, injury or mortality to individuals from gill netting and electrofishing.
- The adverse effects would be offset by the *long-term beneficial effects* on MYLFs in 25 treatment waterbodies and 3.7 mi (6.0 km) of streams contained in seven basins, due to: (1) expected increases in existing MYLF populations to a larger (less-vulnerable) size in response to nonnative trout removal, and (2) the potential for extirpated MYLF populations to be reestablished in restored habitat.

<u>Yosemite Toad</u>
Yosemite toads occur in the northern approximate 20% of the parks, in roughly the area that comprises the northern portion of the San Joaquin/Kings clade of MYLFs (see Figure 5). Amphitheater Basin is the only treated area under this alternative that is located near this area of the parks; however, it is approximately 10 miles from the closest Yosemite toad population, and Yosemite toads have not been observed there (NPS unpublished data). This alternative is therefore expected to have *no effect* on Yosemite toads.

<u>Little Kern Golden Trout</u>
Little Kern golden trout do not occur at any of the treated areas under this alternative. This alternative is therefore expected to have *no effect* on Little Kern golden trout.

<u>Bighorn Sheep</u>
Bighorn sheep occur in one treated area under this alternative (Sixty Lake Basin), but are not expected to be present near treated waterbodies and thus are not expected to be disturbed by treatment activities. 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. This alternative is therefore expected to result in a *may affect, not likely to adversely affect* determination on bighorn sheep.

Cumulative Effects – Alternative A - Special-Status Species
The past, present, and future planned projects that may affect special status species when considering the potential effects of the no action alternative include the past stocking of nonnative fish, ongoing MYLF restoration and research actions within and outside of SEKI, Yosemite toad research and monitoring, projects to recover the Little Kern golden trout, and the recovery actions for Sierra Nevada bighorn sheep. Park operations and emergency actions that involve the use of helicopters may also contribute to

cumulative effects on Sierra Nevada bighorn sheep, depending on the time of year that the helicopter use occurs and the location of the flight and landing zones.

The most substantial past action that has adversely affected MYLFs is nonnative fish stocking throughout the Sierra Nevada. The continued presence of self-sustaining nonnative trout populations in the 550 waterbodies left untreated (contained in 88 basins) would contribute to the continued decline of MYLFs in these areas, and increases the probability of MYLFs to be extirpated within the proposed project area and the parks. No actions considered under this alternative would add substantially to the major adverse effect that occurred to MYLF as a result of this past action. Actions include nonnative fish eradication, intensive field studies, reestablishment of populations in historic habitat, establishment of populations in isolated habitat, and creation or current development of a recovery plans, conservation assessments and/or conservation strategies. The overarching goal of these programs is species recovery, which would result in beneficial effects to these species if successful.

Specifically for the MYLF populations, efforts to reverse the part of the decline of two species in the Sierra Nevada that is primarily the result of past fish stocking actions include the restoration of historically fishless habitat via eradication of nonnative fish populations. In SEKI, fish have been eradicated from 12 waterbodies, 9 treatment areas are in-progress, and 4 were initiated in 2012. In YOSE, eight waterbodies have been approved for nonnative fish eradication; five completed and three in progress (NPS unpublished data). In Inyo and Sierra NFs, nonnative fish have been eradicated or are in-progress toward eradication from 48 waterbodies (CDFW 2011). Recovery efforts are expected to continue throughout the Sierra Nevada for at least the next 15 years. Handling these species for research and recovery activities would result in an adverse effect due to harassment, which considered with the no action alternative means that MYLFs could be adversely affected by these actions across their range in SEKI, YOSE, and on USFS lands. However, the no action alternative, continuing the current program of nonnative fish removal, when considered with other ongoing recovery actions, would contribute slightly to the beneficial effects range-wide on MYLF recovery. The cumulative effects on the MYLFs, if recovery efforts are successful, would be long term and beneficial.

Since the no action alternative would have no effect on Little Kern golden trout, Sierra Nevada bighorn sheep, and Yosemite toad, there would be no cumulative effects.

Conclusion: In addition to the impacts associated with the elements common to all alternatives, alternative A would result in a *may affect, likely to adversely affect* determination in the short term, and *long-term beneficial effects* on a limited population of MYLFs; a *may affect, not likely to adversely affect* determination on Sierra Nevada bighorn sheep; and *no effect* on Yosemite toad and Little Kern golden trout. There would be no substantial cumulative effects on Little Kern golden trout, Sierra Nevada bighorn sheep, and Yosemite toad since there would be only the slight potential for adverse effects to these species under the no action alternative. Cumulative effects on the MYLFs would be adverse and short term considering the numerous research, recovery, and project activities underway across their range, and long term and beneficial if recovery efforts are successful.

Impacts from Elements Common to All Action Alternatives on Special-Status Species

The following is the analyses of those elements common to all alternatives that could have an effect on special-status species. Note that the number of areas affected under the no action alternative is much smaller than under any of the action alternatives, so while the type of impacts would be the same, the geographic scope/extent of those impacts would be much lower.

<u>Crew Camps:</u> Crew camps would need to be established in treatment areas in which nonnative fish are present. Since fish are known to suppress MYLF populations (Knapp et al. 2007), most of the ongoing and proposed treatment areas are expected to have small or extirpated populations of MYLFs. Yosemite

toads are known to occur in or near two proposed treatment areas (McGee and Upper Evolution Basins; USGS unpublished data). Little Kern golden trout hybrids occur in one proposed treatment area (Crytes Basin; NPS unpublished data).

Crew camps are and would be located in upland areas away from water, and thus away from core habitats for any MYLFs, Yosemite toads, and Little Kern golden trout that may be present in the project area. However, crew members walk to nearby water sources to collect buckets of water, and then walk the buckets back to camp for filtering drinking water and washing dishes. If MYLFs, Yosemite toads and Little Kern golden trout were present at a water collection area, this activity may sometimes cause individuals to exhibit a flight response, but the flight response would be no different than what would occur when visitors camp in these areas. These disturbances would be temporary in nature, and any individuals that took flight would typically resume their prior behaviors within a short amount of time.

Bighorn sheep are known to occur in one proposed treatment area (Sixty Lake Basin), and were reintroduced in 2015 to one additional proposed treatment area (Laurel Basin). Crew camps would be located in the valley bottoms of these basins. Since bighorn sheep prefer slopes and ridgelines (FWS 2007B), camps would be away from core habitats for any bighorn sheep that may be present in the project area. Moreover, in areas of the park where sheep and visitors frequently occur in the same general area, such as Upper Soldier Meadow, sheep show a high tolerance for human presence (NPS 2011B). Based on elevation preferences of the sheep and tolerance for people, the presence of crews in the Sixty Lake Basin restoration area is therefore not expected to measurably impact sheep activity, movement or use.

Conclusion: The use of crew camps is, therefore, expected to have no effect on any of the special-status species or their habitat.

<u>Use of Helicopter and Stock:</u> Effects on the special-status species from the use of helicopters and stock to support the mobilization and demobilization of crew camps are expected to be similar to the effects from crew camps. Helicopter or stock would typically travel to and from crew camps in treatment areas twice each summer, and would typically be present for 30 minutes (helicopter) to 2 hours (stock) during each support trip. Stock generally do not remain at the project site overnight, though the more remote sites may require stock to stay nearby in an area approved for overnight use. Crew camps would be located in upland areas away from aquatic habitat for MYLFs, Yosemite toads, and Little Kern golden trout, and in basin bottoms away from ridgeline habitat for bighorn sheep.

Noise from helicopters landing and taking off near crew camps would be temporary and away from the core habitats of special-status species. The use of helicopters is expected to have no effect on MYLFs, Yosemite toad, or Little Kern golden trout because helicopters would be landing outside of their habitat area. The use of helicopters could result in flight response by bighorn sheep; however, mitigation, as listed in chapter 2, would reduce this effect. Therefore the use of helicopters is expected to result in a *may affect, not likely to adversely affect* determination for bighorn sheep.

Similarly, the presence of stock at crew camps would be temporary and stock would be kept away from the core habitats of the special-status species. The use of stock is therefore expected to have no effects on any of the special-status species.

Conclusion: Helicopter and stock support are therefore expected to result in the following effects on special-status species:

- *no effects* on MYLFs, Yosemite toad, and Little Kern golden trout;
- *may affect, not likely to adversely affect* bighorn sheep due to potential for flight responses from helicopter use.

Restoration of Mountain Yellow-Legged Frogs: Two forms of ecosystem restoration involving reestablishment of populations of native species would under each of the alternatives. One form would involve the eradication of nonnative fish and letting native species naturally recolonize the restored habitat. The differing proposed levels of passive ecosystem restoration are analyzed under the no action alternative and three action alternatives.

The other form of restoration would involve human-assisted movement of a number of individuals from extant MYLF populations to other locations, in order to reestablish previously occupied habitat or augment dwindling populations. The effects of this active form of ecosystem restoration and its derivatives are analyzed here. Active restoration would only occur under each of the action alternatives.

Individual MYLFs that are captured would be handled, transported, and released into suitable new habitat, and would experience one of several fates including: survival and subsequent reproduction, survival but no reproduction, or mortality. Some MYLFs may be transported to a captive rearing facility, by foot or helicopter and then vehicle, for captive rearing or head-starting, antifungal treatments, and/or immunizations. The source population of MYLFs would incur a short-term loss of a small percentage of its animals (generally <10%), which would be replaced through reproduction and recruitment over the following several years (Knapp et al. 2011). For example, one healthy MYLF population in YOSE has been used as a source to experimentally reintroduce adults to other fishless lakes that were historically occupied by MYLFs but those populations have recently died out. The source population recovered to approximately pre-removal levels of abundance in three years (Knapp et al. 2011).

There would be potential for individuals in captive MYLF populations to be injured or die, but impacts are expected to be low. In a current experimental MYLF captive rearing study in the San Francisco and Oakland zoos, five of 271 collected animals died during collection, transport and rearing (2%). Although more animals could die during immunization and transport to the wild, the majority of animals are expected to survive captive rearing events and be available for reintroduction. A percentage of the reintroduced animals could die within one year due to predation, low fitness, disease, or winter stress, but enough animals would be expected to survive and breed to provide a chance for population reestablishment. If a reintroduced population could then be augmented with additional animals within 2 to 3 years of the initial release, the potential for successful population reestablishment would increase.

There may be some small MYLF populations that are at risk of complete extirpation if drought causes all fishless habitat in a basin to dry completely. If this scenario appeared likely, the entire population could be captured and transported to a captive rearing facility to establish a captive rearing program and/or head-start tadpoles until the habitat became suitable again for reintroduction. Salvaging drought-threatened species in this way would provide a long-term net benefit to the population in contrast to the potential for high mortality (Lacan et al. 2008) if the population is left alone. For individual MYLFs that are only captured, inserted with a PIT tag, and re-released back into the field for CMR monitoring purposes (i.e., they would not be transported to a new habitat) there would be no local, short-term decline of the local population.

For MYLFs not collected for translocations or reintroductions, and any Yosemite toads that may be present, the restoration activities may cause those individuals to exhibit a flight response, but the flight response would be no different than what would occur when visitors walk by these areas. These disturbances would be temporary in nature, and any individuals that took flight would typically resume their prior behaviors within a short amount of time.

Bighorn sheep are not expected to be present at most MYLF source or recipient site. The two MYLF source or recipient areas where bighorn sheep may be present are Sixty Lakes and Laurel. Mitigation related to helicopter flight lines, as described in chapter 2, would reduce potential adverse effects to the sheep from translocation activities. Research in the Sierra Nevada has shown that humans are not limiting bighorn sheep populations (Hicks and Elder 1979, Wehausen 1980). Bighorn sheep have habituated to human activity in many locations in the Rocky Mountains and in desert habitats (FWS 2007B). Therefore, if sheep were disturbed by crews during translocation activities, it would be expected to result in no more than a slight flight response. Little Kern golden trout do not occur at any potential source or recipient sites, except for the introgressed population in Crytes Basin that is proposed for eradication.

When MYLFs are translocated or reintroduced to a lake site, the typically small number of frogs released is subject to heavy snake predation, which has negative impacts on population viability and thus potential for limiting reintroduction success. Translocation of snakes away from reintroduction sites is expected to improve the success rates of MYLF reintroductions. The impact of snake relocation would have only a positive impact on MYLFs. Snakes would only be relocated to areas that are not occupied by MYLFs, Yosemite toad, or Little Kern golden trout. However, other prey sources would be available for garter snakes, including Pacific treefrogs and small mammals. There would be no impact of snake relocation on bighorn sheep nor would bighorn sheep be anticipated to be present in most of the snake relocation sites.

While these actions would affect individuals, any new populations of MYLFs established or dwindling populations augmented would provide beneficial effects for the long-term conservation of MYLFs within and outside the parks.

Conclusion: Overall, restoration of MYLFs is expected to result in the following effects on the special-status species:

- *no effect* on Yosemite toad and Little Kern golden trout;
- *may affect, not likely to adversely affect* bighorn sheep due to potential for flight responses due to helicopter use for restoration activities;
- *may affect, likely to adversely affect* MYLFs due to the anticipated short-term reduction in population size of the source population, and physical contact and potential for mortality to individuals during and after reintroductions; and long-term beneficial effects if restoration efforts are successful.

<u>Monitoring:</u> Ecosystem monitoring activities associated with each of the alternatives involve monitoring surveys for MYLFs. Surveys are conducted by park staff and researchers from government and non-governmental entities. Scientific measuring devices (such as button sized temperature loggers) are sometimes temporarily placed in survey areas to collect associated habitat data.

Monitoring surveys for MYLFs typically include the use of visual encounter surveys to determine presence, relative abundance, and age structure of populations. This technique involves simply walking around the perimeter of lakes, ponds and meadows, and counting and identifying every animal detected (Crump and Scott 1994). In some surveys, 10 to 30 frogs per population would also be captured using dipnets and temporarily handled to collect skin samples (using sterile swabs) for assessing the presence and infection intensity of amphibian chytrid fungus, to record information about the individual frog (length, sex, behavior), and sometimes marked with Passive Integrated Transponders (PIT tags; for adults) or fluorescent elastomer (for larvae), so they can be identified when they are recaptured.

For MYLFs not handled for swabbing and marking, and any Yosemite toads that may be present, monitoring activities may sometimes cause those individuals to exhibit a flight response, but the flight response would be no different than what would occur when visitors walk by these areas. The placement of temporary scientific measuring such as small electronic sensors that are placed in a lake or stream to periodically measure and record water temperature for up to one year are anticipated to elicit a similar response. These disturbances would be temporary in nature, and any individuals that took flight would typically resume their prior behaviors within a short amount of time. Bighorn sheep are rarely present at MYLF survey habitat (waterbody shorelines) and generally are not affected by human presence. Little Kern golden trout do not occur at any MYLF monitoring sites, except for the introgressed population in Crytes Basin that is proposed for eradication.

While monitoring actions would temporarily disturb individuals, there would be long-term beneficial effects because this work would continue to yield important insights into population status, trends, distribution, and individual survivorship in a landscape where amphibian chytrid fungus is rapidly becoming ubiquitous. This data also provides insight into some of the factors that enable populations to persist to varying degrees despite on-going infection with amphibian chytrid fungus. These insights facilitate the prioritization of sites for fish eradication and for reintroductions and help to identify frog source populations. The knowledge gained through long-term monitoring would continue to be integrated into conservation efforts.

Conclusion*:* Overall, monitoring is expected to result in the following effects on the special-status species:

- *no effects* on Yosemite toad, Little Kern golden trout, and bighorn sheep;
- *may affect, likely to adversely affect* MYLFs due to handling of some individuals and long-term indirect beneficial effects from improved knowledge that would be incorporated into future conservation efforts.

<u>Continuing Research:</u> Continuing research is expected to be critically important for long-term conservation of the special-status species in the parks, especially for MYLFs that have severely declined and are in danger of further declines and possible extinction (CDFW 2011, FWS 2014A). A large body of scientific research has been generated over the past 30 years in investigating possible causes for the MYLF decline and potential solutions for their recovery. This research has been instrumental in documenting the extent of decline (Bradford et al. 1994B, Knapp and Matthews 2000, Vredenburg et al. 2007); determining primary causal factors including nonnative fish (Knapp et al. 2001, Vredenburg 2004, Knapp 2005A) and disease (Rachowicz et al. 2006, Vredenburg et al.2010); showing no to little effect from other factors such as ultraviolet radiation (Vredenburg 2002); and developing solutions including gill-net eradication of nonnative fish (Knapp and Matthews 1998, Vredenburg 2004, Knapp et al. 2007).

Many questions remain unanswered, however, which will require continuing research to help managers develop effective strategies for conservation of native species. In particular, solutions to mitigate the effect of amphibian chytrid fungus on MYLFs are very much needed. Three areas of potential promise include refining methods to (1) bathe MYLFs in an anti-fungal solution (e.g., itraconazole) to reduce amphibian chytrid levels on frog skin, (2) augment naturally occurring bacteria to frog skin (e.g., *J. lividum*) to increase natural protection from amphibian chytrid fungus, and (3) reestablish MYLF populations where they historically occurred or are dwindling toward extirpation due to amphibian chytrid fungus.

Itraconazole is an anti-fungal compound that has been used extensively to clear amphibian chytrid fungus from amphibians, typically in a laboratory setting. In recent field experiments in the parks it was used to clear or substantially reduce amphibian chytrid fungus loads on MYLFs in three populations in the parks (Knapp 2009, 2010, 2011). In each population as many MYLFs as possible were captured, held in temporary enclosures, and bathed in a low-concentration solution of itraconazole for 10 minutes a day for 7 consecutive days. Treatments done in 2009 (in Sixty Lake and Barrett Basins), and 2010 and 2012 (in Dusy Basin) were all successful in clearing or substantially reducing loads of amphibian chytrid fungus, with no detected direct mortality from the treatments, and high survival through the end of summer as determined by subsequent monitoring.

Based on population monitoring during the summer following treatment, the treatment did not increase the long-term survival of tadpoles or juveniles, but markedly increased the survival of adults (adults were only available in Sixty Lake Basin). These adult frogs continue to persist (through 2015) and now typically have low amphibian chytrid fungus loads that are characteristic of populations in which frogs are persisting despite ongoing chytridiomycosis. The different treatment outcomes between tadpoles/juveniles and adults is likely a consequence of life stage-specific differences in the strength of the frog immune response against amphibian chytrid fungus. Collectively, these results suggest that if treatment of infected adult MYLFs with itraconazole can sustain adults until recruitment starts to occur, then it can change the outcome of amphibian chytrid fungus epidemics from population extirpation to persistence. Additionally, in contrast to MYLFs, Hardy et al. (2015) found that itraconazole increased survival of juvenile Cascades frogs (*Rana cascadae*). If additional trials show itraconazole can increase survival of juvenile MYLFs in certain populations, then it would be considered for use in this project.

The bacterium *J. lividum* has strong anti-fungal properties and is found naturally on the skin of several amphibians including MYLFs in the Sierra Nevada. This bacterium produces the anti-amphibian chytrid metabolite violacein and may help to protect frogs from fungal diseases including chytridiomycosis. Laboratory research showed that augmenting the concentration of *J. lividum* on the skins of MYLFs provided some protection from amphibian chytrid fungus and prevented chytridiomycosis-caused frog mortality (Harris et al. 2009). In the parks in 2010, a field trial was conducted in which recently infected adult MYLFs in Dusy Basin were treated with *J. lividum* to increase the concentration of this bacterium on their skin. *J. lividum* was collected from Dusy Basin frogs, cultured in the laboratory, and then used to augment *J. lividum* concentrations on 80 frogs. The treatment was conducted over one or two days by bathing frogs in a concentrated *J. lividum* solution for one hour each day (Knapp 2010).

Subsequent monitoring showed much higher survival through the end of summer compared to frogs that were not treated. In 2011, 20 to 30 frogs were detected during each of several surveys through the summer and all of these frogs had been treated with *J. lividum*, suggesting that probiotic treatment may be effective at helping MYLF populations survive an amphibian chytrid epidemic. Another experiment was conducted in Dusy Basin in 2012 to assess whether *J. lividum* treatments applied to juveniles could increase their survival. Highly infected juveniles (recent metamorphs) were captured from a single population, treated with Itraconazole for 7 days to reduce their disease loads, and then treated with *J. lividum* on two consecutive days. Over the 2012 summer, survival of treated frogs was much higher than untreated control frogs, but monitoring in 2013 detected only one treated frog in early summer, and then no survivors in mid- and late-summer (Knapp R., unpublished data). Therefore, treatment of adult frogs may confer long-term survival benefits, but thus far treatment of juveniles does not appear to confer long-term benefits.

Recent actions to reduce infection levels in MYLFs demonstrated no reduction in survival that could be causally attributed to the treatments (Knapp 2009, 2010). The only MYLFs that died during treatments had already reached catastrophic levels of amphibian chytrid infection. All other treated MYLFs survived the treatments, were fully or nearly cleared of infection, and had substantially higher survival than untreated control animals. Although animals have minimal foraging ability during treatments, all treated animals appeared to have typical behavior and energy levels upon release, and several individuals have been observed actively foraging immediately after release (Knapp and NPS, pers. obs.).

Individual MYLFs captured for anti-fungal bathing or bacterial additions would be handled, treated, and released. For MYLFs not collected for treatments, and any Yosemite toads that may be present, the treatment activities may sometimes cause those individuals to exhibit a flight response, but the flight response would be no different than what would occur when visitors walk by these areas. These disturbances would be temporary in nature, and any individuals that took flight would typically resume their prior behaviors within a short amount of time. Bighorn sheep are not expected to be present at a source or recipient site. Little Kern golden trout do not occur at any potential source or recipient sites.

While these actions would disturb individuals, any populations of MYLFs that survive the amphibian chytrid infection after treatment would improve the long-term conservation of MYLFs as individuals become more resistant to amphibian chytrid fungus and populations increase and become less vulnerable.

Conclusion: Overall, continuing research is expected to result in the following effects on the special-status species:

- *no effect* on Yosemite toad, Little Kern golden trout, and bighorn sheep;
- *may affect, likely to adversely affect* MYLFs due to physical contact and potential for mortality to individuals during and after treatments, but long-term beneficial effects due to increased resistance to amphibian chytrid fungus.

<u>Fish Disposal:</u> Nonnative fish removed by gill-netting and electrofishing from ongoing, planned, and proposed treatment areas are typically sunk to the bottom of fish-removal lakes to allow the nutrients contained in fish populations to be decomposed and released to the local ecosystem. Small numbers of fish removed by electrofishing are occasionally sunk in fish-removal streams. This onsite decomposition process is important because the parks' high elevation aquatic ecosystems are oligotrophic environments, meaning they naturally have low nutrient levels for sustaining life (Sickman and Melack 1992). The energy contained in populations of nonnative fish, which often contain thousands of fish, needs to be kept onsite and released back to the native ecosystem through decomposition to avoid the loss of those valuable nutrients. Fish are sunk as they are caught over the 2 to 6 year period until eradication is achieved. A majority of fish are captured within the first year (NPS 2015A), which may result in a large initial pulse of nutrients back into the system. Over a 13-year period of time (2001 to 2013), the parks removed a total of 50,201 nonnative fish from 23 lakes and associated streams, with complete eradication from 10 lakes, near eradication from nine lakes, and initial progress toward eradication in four lakes. The decomposition of these fish appears to have had no visible adverse effects to the special-status species, and may have had a beneficial effect in contributing to the very large increase in MYLF populations measured in the treatment areas. For example, in nine lakes eradicated of fish in which MYLFs remained disease-free three years after fish removal, average density (tadpoles + frogs) increased by 13-fold (from 1.6 to 21.1 per 10 m /32 ft of shoreline; NPS 2012A); one lake showed a 49-fold increase (from 0.9 to 43.9 per 10 m /32 ft of shoreline). Several of these restored populations are now among the largest in the entire range of MYLFs.

This nutrient pulse may benefit both species of MYLF and the Yosemite toad for a short period of time. Restoration efforts in subsequent years generally result in progressively lower fish captures, which trail off as eradication nears completion and nutrient levels are returned to pretreatment conditions.

Bighorn sheep are known to occur in one proposed treatment area (Sixty Lake Basin) and were reintroduced in 2015 to one additional proposed treatment area (Laurel Basin; NPS 2011B). However, bighorn sheep graze upland vegetation and therefore the likelihood that they would be at a disposal area during project work would be low.

Yosemite toads are known to occur in or near two proposed treatment areas (Upper Evolution and McGee Basins). If individual MYLFs or Yosemite toads were present near a fish disposal area, this activity may sometimes cause individuals to exhibit a flight response, but the flight response would be no different than what would occur when visitors walk by these areas. These disturbances would be temporary in nature, and any individuals that took flight would typically resume their prior behaviors within a short amount of time.

Fish disposal would therefore have no adverse effects on MYLFs, Yosemite toads, and bighorn sheep.

Little Kern golden trout occur in one proposed treatment area (Crytes Basin). However, this population is an introduced, nonnative population occupying historically fishless habitat and is not part of the recovery plan for this species (Christenson 1984). In addition, recent sampling shows that the fish in this population have an introgressed genetic structure (meaning they are not genetically pure; Erickson et al. 2010). These fish therefore have degraded value for any current of future restoration of Little Kern golden trout within their native range (Karuzas J., pers. comm., 2012). This population is proposed for eradication under the action alternatives in order to benefit native species. Fish disposal would therefore have no effect on native Little Kern golden trout because they would already have been removed from the treatment area. Potential effects on Little Kern golden trout due to the differing proposed levels of fish removal are analyzed under the no action alternative and three action alternatives.

Conclusion: Fish disposal is therefore expected to result in the following effects on the special-status species:

- *no effect* on any of the special-status species;
- short-term beneficial effects on the Yosemite toad and MYLFs resulting from a short-term increase in nutrients available for growth in fish disposal areas proximate to their habitat.

Cumulative Effects from Elements Common to All Action Alternatives on Special-Status Species

The past, present, and future planned projects that may affect special status species when considering the elements common to all alternatives include ongoing MYLF restoration and research actions within and outside of SEKI, Yosemite toad research and monitoring, projects to recover the Little Kern golden trout, and the recovery actions for Sierra Nevada bighorn sheep. Park operations and emergency actions that involve the use of helicopters may also contribute to cumulative effects on Sierra Nevada bighorn sheep, depending on the time of year that the helicopter use occurs and the location of the flight and landing zones.

As explained under alternative A, the largest past action that has adversely affected MYLF is nonnative fish stocking actions throughout the Sierra Nevada. No actions from the elements common to all alternatives would come close to matching or adding to the adverse effects that occurred to MYLF as a result of this past action. Restoration, research, and recovery actions may result in short-term adverse effects on special status species, primarily from the potential to harass and harm these species by physical contact during project work. These projects have strict requirements from the USFWS as a result of the permitting process. While there could be short-term adverse effects, in the long term, there would be beneficial effects to the species from increased knowledge, restoration and/or preservation of habitat, and if successful, restoration and protection of the species. When considered with the effects to listed species from the elements common to all alternatives, the cumulative effects on MYLF would be slight and adverse, and could result in substantial long-term beneficial cumulative effects.

The use of helicopters to transport equipment and supplies to the project site and for maintenance and emergency operations may affect Sierra Nevada bighorn sheep, which may exhibit a flight response. Flight activities have occurred over bighorn sheep areas, and are expected to occur in the future, both for project work and for emergency operations (primarily search and rescue). Helicopter pilots are instructed to avoid flying over occupied habitat, however in some situations this is not possible (i.e. emergencies). When considering that few flights would occur for this and other projects over occupied bighorn sheep habitat and that any flights that occur would avoid, to the extent possible, occupied bighorn sheep habitat, the cumulative effects may affect, but are unlikely to adversely affect bighorn sheep. There would be no cumulative effects from the elements common to all alternatives on Yosemite toads and Little Kern golden trout as these species are not affected by these project activities.

Impacts of Alternative B: Prescription Treatment Preceding Restoration (Preferred Alternative) on Special-Status Species

Under this alternative, nonnative fish would be removed from 85 waterbodies (31 lakes, 49 ponds, 5 marshes) and approximately 31 mi (50 km) of connected stream habitat contained in 21 basins (see Table 9, Table 10 and Table 11, and Figure 7 in chapter 2). Nonnative fish would be removed using physical methods (gill netting and electrofishing) from 52 waterbodies (27 lakes, 24 ponds, 1 marsh) and approximately 15 mi (25 km) of stream contained in 17 basins. Nonnative fish would be removed using piscicides (rotenone) from 33 waterbodies (4 lakes, 25 ponds, 4 marshes) and approximately 16 mi (25 km) of streams contained in 9 basins.

<u>Mountain Yellow-legged Frogs</u>
Removal of nonnative fish from the additional 85 treatment waterbodies and 31 mi (50 km) of streams contained in 21 basins included in this alternative would provide substantial long-term beneficial effects on MYLFs, due to: (1) expected increases in existing MYLF populations to a larger (less-vulnerable) size, and (2) the potential for extirpated MYLF populations to be reestablished in restored habitat. These 85 waterbodies comprise 15% of the parks' 550 high elevation waterbodies that will continue to have fish after completing the current fish eradication work (no action alternative).

Effects on MYLFs due to gill netting, electrofishing and crew activities would be the same in nature as those described under alternative A. Because the number of sites treated using these methods (52 waterbodies and approximately 15 mi / 25 km of streams) would be greater than the number of sites treated under alternative A (25 waterbodies and 3.7 mi/6.0 km of streams), a larger number of individual MYLFs would be adversely affected compared to no action.

In addition, fish traps may be used to facilitate fish eradication in areas with extensive amounts of stream habitat containing high-densities of fish. Fish traps are expected to have no effect on MYLFs for the following reasons. First, few to no MYLFs occur in habitat with high density fish populations (Knapp et al. 2005). Second, MYLFs that may be present would likely not colonize a trap full of nonnative fish because they are able to sense fish presence (Vredenburg 2004) and thus would be expected to avoid predatory fish when possible. Therefore, the potential for disturbance, injury or mortality to MYLF individuals due to fish traps is expected to be extremely low.

Under this alternative, 33 waterbodies and approximately 16 mi (25 km) of streams would also be treated using piscicides. 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.

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 0.5 ppm (=25 ppb rotenone) in streams and 1 ppm (=50 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.

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. If distressed tadpoles are observed in a treatment area, park staff would attempt to move them to clean buckets of water or directly to untreated habitat to try to keep them from dying. 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 0.5 to 1.0 ppm (=25 to 50 ppb rotenone) in streams and 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 (Billman et al. 2012), 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 (including oxygen) uptake from water is much lower than tadpoles or fish (Seymour 1999, 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 (Billman et al. 2012). The eradication of nonnative trout from the piscicide treatment waterbodies would provide a large increase in habitat for the MYLFs occupying these basins, with corresponding benefits over time of enhanced survival, growth and reproduction.

Many of the waterbodies eradicated of fish would be large, deep and /or cold waterbodies that would provide substantially enhanced habitat for remnant MYLF populations currently restricted to small, shallow ponds. Treatment sites would provide these MYLF populations with large areas of fishless habitats that have high capacity to buffer drying and warming expected over time, thus allowing for the persistence of MYLFs in a period of rapid and unprecedented change.

Overall, this alternative is expected to result in the following effects on MYLFs:

- *may affect, likely to adversely affect* MYLFs in up to 85 additional treated waterbodies due to the potential for disturbance, injury or mortality to individuals from gill netting and electrofishing in 52 waterbodies and approximately 15 mi (25 km) of streams contained in 17 basins; and from piscicides in 33 waterbodies and approximately 16 mi (25 km) of streams contained in 9 basins.
- These adverse effects would be offset by the *long-term beneficial effects* on MYLFs in 85 additional treated waterbodies and 31 mi (50 km) of streams contained in 21 basins, due to: (1) expected increases in existing MYLF populations to a larger (less-vulnerable) size in response to nonnative trout removal, and (2) the potential for extirpated MYLF populations to be reestablished in restored habitat.

<u>Yosemite Toad</u>
Yosemite toads were recently detected in two of the proposed treatment basins under this alternative (McGee and Upper Evolution; USGS unpublished data), but are not expected to be present in any of the

remaining treatment basins under this alternative. The majority of fish-removal actions under this alternative would therefore have no effect on the Yosemite toad.

All of the treatment waterbodies in McGee Basin and most of the treatment waterbodies in Upper Evolution are proposed for physical fish-removal (gill netting, electrofishing, trapping, and disruption and/or covering of redds). The recent detections of Yosemite toads in these areas was in habitat adjacent to (outside) the proposed treatment waterbodies in Upper Evolution, and in habitat on the edge of the proposed treatment waterbodies in McGee. Thus there is low potential for Yosemite toads to be adversely affected by gill netting and electrofishing in McGee and Upper Evolution. Nevertheless, there would be potential for a small number of Yosemite toads to get caught in gill nets and/or electrofishing fields during the treatment period in these areas.

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 (breeding occurs from mid-May to mid-August) 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 above under the "Mountain Yellow-legged Frogs" section would be implemented, which would further reduce the number Yosemite toads that would be affected by the treatment. These situations and mitigations make the possibility of an effect on toads highly unlikely (discountable).

Nevertheless, if tadpoles are present, and they cannot be captured and moved, they would be expected to be affected by the treatment. Although no rotenone toxicity data exist for toad species, Yosemite toad tadpoles are likely to have similar 24 hr LC50 concentrations as leopard frog tadpoles (5 to 30 ppb rotenone). Although CFT Legumine™ application concentrations (=25 to 50 ppb rotenone) exceed the expected 24 hr LC50 concentration for Yosemite toad tadpoles, tadpoles present in August or September would be older tadpoles. Therefore, if any tadpoles are still present at that time of year in the treatment site, the treatment would result in some-tadpoles being killed, and some may be affected but would survive. If distressed tadpoles are observed in a treatment area, park staff would attempt to move them to clean buckets of water or directly to untreated habitat to try to keep them from dying.

If adult toads are present, and they are not able to be captured and moved, they would not be expected to be harmed by the treatment (Billman et al. 2012). Yosemite toad adults likely have similar 24 hr LC50 concentrations as leopard frog adults (240 to 1,580 ppb rotenone). CFT Legumine™ application concentrations (25 to 50 ppb rotenone) do not exceed the expected 24 hr LC50 concentration for Yosemite toad adults. Therefore, Yosemite toad adults exposed to the piscicide treatment would not be expected to be killed, although some may be affected but would survive.

Although the "capture and move" mitigation as described in chapter 2 is expected to minimize any treatment effects on individuals in the two populations adjacent to the treatment waterbodies, this alternative has the potential to have a small impact on Yosemite toads.

Overall, this alternative is expected to result in the following effects on Yosemite toads:

- *no effect* in 19 of the 21 treatment basins;
- *may affect, likely to adversely affect* in Upper Evolution and McGee. It is unlikely that Yosemite toads would be affected by the treatments because it is unlikely that they would be present during treatments and the mitigations are expected to be successful. There would be a possibility for

long-term beneficial effects due to the elimination of nonnative trout, which would reduce competition for food and possibly predation.

Little Kern Golden Trout

Little Kern golden trout occur in one of the treatment basins under this alternative (Crytes) and are not expected to be present in any of the remaining treatment basins under this alternative. The majority of fish-removal actions under this alternative would therefore have no effect on Little Kern golden trout.

This alternative proposes to eradicate fish from Crytes using a combination of physical methods (i.e. gill netting and electrofishing in one lake and one lake/pond complex) and piscicides (rotenone in adjacent stream and marsh areas). 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 genetic 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.

Overall, this alternative is expected to have the following effects on Little Kern golden trout:

- *no effect* in 20 of the 21 treatment basins;
- *may affect, likely to adversely affect* in Crytes due to the eradication of this population of Little Kern golden trout.

Bighorn Sheep

Bighorn sheep occur in one of the treatment basins under this alternative (Sixty Lake) and were reintroduced in 2015 in one additional treatment basin (Laurel). Bighorn sheep are not expected to be present in any of the remaining treatment basins under this alternative. The majority of fish-removal actions under this alternative would therefore have no effect on 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). Existing rotenone toxicity data for mammals only analyze effects from consuming fish killed by rotenone. Bighorn sheep are herbivores and thus do not typically consume fish or other animals. In addition, as most fish will be sunk, dietary exposure of bighorn sheep is unlikely.

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.

Overall, this alternative is expected to have the following effects on bighorn sheep:

- *no effect* in 19 or 20 of the 21 treatment basins;
- *may affect, not likely to adversely affect* in Sixty Lake and potentially Laurel basins due to the insignificant and discountable likelihood of effects.

Cumulative Effects – Alternative B - Special-Status Species
As described under alternative A, the past stocking of nonnative fish, and restoration actions and studies for the conservation of native species in high elevation ecosystems of the southern Sierra Nevada comprise the past, present, and potential future actions that have the potential to affect MYLFs, Little Kern golden trout, California golden trout, Kern River rainbow trout, and Sierra Nevada bighorn sheep. Under this alternative, nonnative trout would continue to contribute to the decline of MYLFs in the 465 untreated waterbodies plus connecting streams (contained in 69 basins), which reduces the number of areas where MYLFs could possibly be extirpated as compared to the no action alternative. Restoration actions, including nonnative fish eradication, intensive field studies, reestablishment of populations in historic habitat, establishment of populations in isolated habitat, and creation or current development of recovery plans, conservation assessments and/or conservation strategies could have short-term adverse cumulative effects on these species from handling actions and activities that cause disturbance. However, the goal of these programs is species recovery, which would result in long-term beneficial effects on these species if successful.

This alternative would contribute to the short-term adverse effects to MYLFs that are occurring in the Sierra Nevada region as a result of restoration and research activities, primarily due to increased handling of MYLF and increased potential for harassment and harm. However, this alternative would contribute substantially to the beneficial effects that are occurring Sierra-wide from restoration and research activities specifically for the MYLF. If the restoration work proposed under this alternative is successful, when weighed with the actions occurring elsewhere in the Sierra Nevada, the cumulative effects on MLYF recovery range-wide would be long-term and beneficial.

As described under alternative A, research is ongoing for the Yosemite toad, resulting in more knowledge about the species and potential impacts to the species from handling actions. While this alternative may result in slight adverse effects in two treatment basins if toads are present during treatment, the overall cumulative effect would be adverse and slight, and difficult to discern.

Restoration activities elsewhere are benefiting the Little Kern golden trout. One population could be adversely affected under this alternative. However, this population, according to the Recovery Plan, is not necessary for the recovery of the species, is not native to the basin, and is genetically compromised. Therefore, the removal of this population, while evident and observable is still relatively small in proportion to the overall beneficial cumulative effect from ongoing recovery actions. Therefore, the cumulative effect from this alternative would be adverse and slight.

This project would have the potential to slightly impact Sierra Nevada bighorn sheep from disturbance associated with project work, and the slight potential for sheep to drink water treated with piscicide. These effects, when weighed against other project work involving bighorn sheep, is such a small increment that cumulative effects are extremely difficult to discern. Therefore, in project areas that overlap with bighorn sheep habitat, the cumulative effects would be short- and long-term negligible and adverse.

Conclusion: Alternative B would result in a *may affect, likely to adversely affect* determination, and *long-term beneficial effects* on the MYLFs; *no effect* on Yosemite toad in 19 treated basins and a *may affect, likely to adversely* affect determination for two treatment basins (Upper Evolution and McGee); no effect on the Little Kern golden trout in 20 treated basins, but a *may affect, likely to adversely affect* determination in Crytes; and *no effect* on Sierra Nevada bighorn sheep in 19 treated basins, and *a may affect, not likely to adversely affect* determination in Sixty Lake and Laurel. There would be no discernable or slight adverse cumulative effects on the Little Kern golden trout, Sierra Nevada bighorn sheep, and Yosemite toad. Cumulative effects on the MYLFs would be adverse and short term considering the numerous ongoing and future planned research, recovery, and project activities, and long term and beneficial if recovery efforts are successful.

Impacts of Alternative C: Physical Treatment Preceding Restoration on Special-Status Species
Under this alternative, nonnative fish would be removed using physical methods only (gill netting and electrofishing) from 52 waterbodies (27 lakes, 24 ponds, 1 marsh) and approximately 15 mi (25 km) (of streams contained in 17 basins (see Table 9 and Table 14, and Figure 9 in chapter 2). Blasting rock to create vertical fish barriers in these physical treatment areas would be conducted (if necessary) at up to five natural cascades.

<u>Mountain Yellow-legged Frogs</u>
Removal of nonnative fish from the additional 52 treated waterbodies and approximately 15 mi (25 km) of streams included in this alternative would provide long-term beneficial effects on MYLFs, due to: (1) expected increases in existing MYLF populations to increase to a larger (less-vulnerable) size, and (2) the potential for extirpated MYLF populations to be reestablished in restored habitat. However, these 52 waterbodies comprise 9% of the parks' 550 high elevation waterbodies that will contain nonnative trout after completion of the current (previously approved) treated waterbodies described in alternative A (no action). Effects on MYLFs due to gill netting, electrofishing and crew activities would be the same as described under alternative A, except that an additional 52 waterbodies and approximately 15 mi (25 km) of streams would be treated.

Effects on MYLFs due to blasting rock, if determined necessary to create self-maintaining vertical fish barriers, would include the following. First, it is estimated that blasting would be necessary at no more than five natural cascades over the duration of the project. Second, blasting would occur in late summer when streams are at their lowest flows of the season. Third, MYLF tadpoles are unlikely be present in blasting areas because cascades are too steep to have pools present as habitat for tadpoles. Any MYLF adults or juveniles present as crews begin work would exhibit a flight response, but these disturbances would be temporary in nature, and any individuals that took flight would typically resume their prior behaviors in a distant location within a short amount of time. However, there is slight potential for

MYLFs to seek cover within the immediate work area rather than exhibiting a flight response out of the work area. If this occurred, there would be potential for those individuals to be injured or killed during a blast, either from the force of the blast or by rock projectiles. Any injury or mortality to individual MYLFs from blasting would have negligible to minor effects on the local populations of those species. In the long-term, blasting rock to create vertical fish barriers would allow certain treatment areas to be fully eradicated of trout, which would result in long-term beneficial effects to MYLFs.

Overall, this alternative is expected to result in the following effects on MYLFs:

- *may affect, likely to adversely affect* MYLFs in up to 52 additional treatment waterbodies and approximately 15 mi (25 km) of streams contained in 17 basins, due to the potential for disturbance, injury, or mortality to individuals from gill netting and electrofishing (and from blasting, if necessary, in up to five locations).
- These adverse effects would be offset by the *long-term beneficial effects* on MYLFs in the 52 additional treatment waterbodies and approximately 15 mi (25 km) of streams, due to: (1) expected increases in existing MYLF populations to a larger (less-vulnerable) size in response to nonnative trout removal, and (2) the potential for extirpated MYLF populations to be reestablished in restored habitat.

In comparison to the 85 waterbodies and 31 mi (50 km) of streams contained in 21 basins proposed for fish eradication in alternative B, the 52 waterbodies and 15 mi (25 km) of streams contained in 17 basins proposed for fish eradication in this alternative would capture less: (1) geographic and elevational representation of the historic distribution of MYLFs, (2) known genetic diversity of MYLFs, (3) areas of potential high-quality habitat, and (4) known persistent MYLF populations important to future restoration.

<u>Yosemite Toad</u>
Yosemite toads were recently detected in two of the treatment basins under this alternative (Upper Evolution and McGee; USGS unpublished data) and are not expected to be present in any of the remaining treatment basins under this alternative. The majority of fish-removal actions under this alternative would therefore have no effects on the Yosemite toad.

Effects on Yosemite toads due to gill netting, electrofishing, and crew activities would be the same as described under alternative B.

Effects on Yosemite toads due to blasting (if necessary) would be the same as described in the “Mountain Yellow-legged Frogs” section of alternative C above.

Overall, this alternative is expected to result in the following effects on Yosemite toads:

- *no effect* in 15 of the 17 treatment basins;
- *may affect, likely to adversely affect* in Upper Evolution and McGee. It is unlikely that Yosemite toads would be affected by the treatments because it is unlikely that they would be present during treatments and the mitigations listed in chapter 2 are expected to be successful. There would be a possibility for long-term beneficial effects due to the elimination of nonnative trout, which would reduce competition for food and possibly predation.

<u>Little Kern Golden Trout</u>
Little Kern golden trout occur in one of the treatment basins under this alternative (Crytes) and are not expected to be present in any of the remaining treatment basins under this alternative. The majority of fish-removal actions under this alternative would therefore have no effect on Little Kern golden trout.

This alternative proposes to eradicate fish from part of Crytes using physical methods (gill netting and electrofishing only in one lake and one lake/pond complex), and blasting (if necessary) in one location. Effects on Little Kern golden trout due to gill netting and electrofishing would be the same as described under alternative B. Effects on Little Kern golden trout due to blasting would be the same as described in the "Mountain Yellow-legged Frogs" section under alternative C.

Overall, this alternative is expected to have the following effects on Little Kern golden trout:

- *no effect* in 16 of the 17 treatment basins;
- *may affect, likely to adversely affect* in Crytes due to the eradication of this population of Little Kern golden trout.

<u>Bighorn Sheep</u>
Bighorn sheep do not occur in any of the treatment basins under this alternative and thus are not expected to be present. This alternative would therefore have *no effect* on bighorn sheep.

Cumulative Effects – Alternative C – Special-Status Species
The cumulative effects on the MLYFs, Yosemite toad, and Little Kern golden trout are the same as described under alternative B. The continued presence of self-sustaining nonnative trout populations in the 498 waterbodies plus connecting streams left untreated (contained in 80 basins) would contribute to the continued decline of MYLFs in these areas, and increases the probability that MYLFs would be extirpated outside the proposed project area. There would be no cumulative effects on the Sierra Nevada bighorn sheep since they do not occur in the treatment basins proposed under this alternative.

Conclusion: Alternative C would result in a *may affect, likely to adversely affect* determination, and *long-term beneficial effects* on the MYLFs; *no effect* on Yosemite toad in 15 treated basins and a *may affect, likely to adversely affect* determination for two treated basins (Upper Evolution and McGee); *no effect* on the Little Kern golden trout in 16 treated basins, but *a may affect, likely to adversely affect* determination in Crytes; and, *no effect* on Sierra Nevada bighorn sheep. There would be no discernable or only slight cumulative effects on Little Kern golden trout, Sierra Nevada bighorn sheep, and Yosemite toad. Cumulative effects on the MYLF would be adverse and short term considering the numerous ongoing and future planned research, recovery, and project activities, and long term and beneficial if recovery efforts are successful.

Impacts of Alternative D: Piscicide Treatment Preceding Restoration on Special-Status Species
Under this alternative, nonnative fish would be removed using piscicides only (rotenone) from 85 waterbodies (31 lakes, 49 ponds, 5 marshes) and approximately 31 mi (50 km) of connected stream habitat contained in 21 basins (see Table 9 and Table 15, and Figure 10 in chapter 2).

<u>Mountain Yellow-legged Frogs</u>
Removal of nonnative fish from the 85 additional treatment waterbodies and 31 mi (50 km) of streams included in this alternative would provide long-term beneficial effects on MYLFs, due to: (1) expected increases in existing MYLF populations to larger (less-vulnerable) size, and (2) the potential for extirpated MYLF populations to be reestablished in restored habitat. However, these 85 waterbodies comprise 15% of the parks' 550 high elevation waterbodies that will contain nonnative fish after completion of the current (previously approved) treated waterbodies described in alternative A (no action). Effects on MYLFs due to crew activities would be the same as described under alternative A, except that these activities would take place at an additional 85 waterbodies and 31 mi (50 km) of streams. Effects on MYLFs due to piscicides would be the same as described under alternative B, except that piscicide treatment would occur at 52 more waterbodies and approximately 15 more miles (25 km) of streams.

Overall, this alternative is expected to result in the following effects on MYLFs:

- *may affect, likely to adversely affect* MYLFs in up to 85 additional treatment waterbodies and 31 mi (50 km) of streams contained in 21 basins due to the potential for disturbance, injury or mortality to individuals from piscicides.
- These adverse effects would be offset substantially by the *long-term beneficial effects* on MYLFs in 85 additional treatment waterbodies and 31 mi (50 km) of streams contained in 21 basins, due to (1) expected increases in existing MYLF populations to a larger (less-vulnerable) size in response to nonnative trout removal, and (2) the potential for extirpated MYLF populations to be reestablished in restored habitat.

In comparison to alternative B, the same 85 waterbodies are being proposed for fish eradication in alternative D. However, this alternative would more quickly restore habitat within the: (1) geographic and elevational representation of the historic distribution of MYLFs, (2) known genetic diversity of MYLFs, (3) areas of potential high-quality habitat, and (4) known persistent MYLF populations important to future restoration.

<u>Yosemite Toad</u>
Yosemite toads were recently detected in two of the treatment basins under this alternative (Upper Evolution and McGee; USGS unpublished data) and are not expected to be present in any of the remaining treatment basins under this alternative. The majority of fish-removal actions under this alternative would therefore have no effects on the Yosemite toad.

Effects on Yosemite toads due to piscicides treatment would be the same as described under alternative B, although these activities would occur on a much broader scale.

Overall, this alternative is expected to result in the following effects on Yosemite toads:

- *no effect* in 19 of the 21 treatment basins;
- *may affect, likely to adversely affect* in Upper Evolution and McGee. It is unlikely that Yosemite toads would be affected by the treatments because it is unlikely that they would be present during treatments and the mitigations are expected to be successful. There would be a possibility for long-term beneficial effects due to the elimination of nonnative trout, which would reduce competition for food and possibly predation.

<u>Little Kern Golden Trout</u>
Little Kern golden trout occur in one of the treatment basins under this alternative (Crytes) and are not expected to be present in any of the remaining treatment basins under this alternative. The majority of fish-removal actions under this alternative would therefore have no effects on Little Kern golden trout.

This alternative proposes to eradicate fish from part of Crytes using piscicides. Effects on Little Kern golden trout would be the same as described under alternative B.

Overall, this alternative is expected to have the following effects on Little Kern golden trout:

- *no effect* in 20 of the 21 treatment basins;
- *may affect, likely to adversely affect* in Crytes due to the eradication of this population of Little Kern golden trout.

<u>Bighorn Sheep</u>
Bighorn sheep occur in one of the treatment basins under this alternative (Sixty Lake) and were reintroduced in 2015 to one additional treatment basin (Laurel). Bighorn sheep are not expected to be

present in any of the remaining treatment basins under this alternative. The majority of fish-removal actions under this alternative would therefore have no effect on bighorn sheep.

This alternative proposes to eradicate fish from Sixty Lake and Laurel using piscicides (rotenone). Effects on bighorn sheep would be the same as described under alternative B.

Overall, this alternative is expected to have the following effects on bighorn sheep:

- *no effect* in 19 of the 21 treatment basins;
- *may affect, not likely to adversely affect* in Sixty Lake and Laurel due to the insignificant and discountable likelihood of effects.

Cumulative Effects – Alternative D – Special-Status Species
The cumulative effects on the MYLFs, Yosemite toad, Little Kern golden trout, and Sierra Nevada bighorn sheep would be the same as described under alternative B. The continued presence of self-sustaining nonnative trout populations in the 465 waterbodies left untreated (contained in 69 basins) would contribute to the continued decline of MYLFs in these areas, and increases the probability of MYLFs to be extirpated outside the proposed project area. Cumulative effects on the MYLF would be adverse and short term considering the past action of stocking nonnative trout, and the numerous ongoing and future planned research, recovery, and project activities, and long term and beneficial if recovery efforts are successful. There would be no discernable or only slight cumulative effects on Little Kern golden trout, Sierra Nevada bighorn sheep, and Yosemite toad.

Conclusion: Alternative D would result in a *may affect, likely to adversely affect* determination, and *long-term beneficial effects* on the MYLFs; *no effect* on Yosemite toad in 19 treated basins and a *may affect, likely to adversely affect* determination for two treatment basins (Upper Evolution and McGee); *no effect* on the Little Kern golden trout in 20 treated basins, but a *may affect, likely to adversely affect* determination in Crytes; and, *no effect* on Sierra Nevada bighorn sheep in 19 treated basins, and a *may affect, not likely to adversely affect* determination in Sixty Lake and Laurel. There would be no discernable or slight adverse cumulative effects on Little Kern golden trout, Sierra Nevada bighorn sheep, and Yosemite toad. Cumulative effects on the MYLF would be adverse and short term considering the numerous ongoing and future planned research, recovery, and project activities, and long term and beneficial if recovery efforts are successful.

WILDLIFE (INCLUDING VERTEBRATES AND INVERTEBRATES)

METHODOLOGY FOR ANALYZING IMPACTS

The NPS *Organic Act*, which directs parks to conserve wildlife unimpaired for future generations, is interpreted to mean that native animal life should be protected and perpetuated as part of the parks' natural ecosystems. Natural processes are relied on to control populations of native species to the greatest extent possible and these species are protected from harvesting, harassment, or harm by human activities. According to NPS *Management Policies* 2006 (NPS 2006A), the restoration of native species is a high priority (section 4.1). For this analysis, impacts were assessed based on meeting management goals for wildlife which include maintaining components and processes of naturally evolving park ecosystems, including natural abundance, diversity, and the ecological integrity of plants and animals (Table 22). Information on the parks' wildlife was gathered from park documents and records and provided by the parks' natural resource management staff. Analysis of environmental consequences for wildlife is subdivided into native vertebrates and invertebrates. The wildlife species that occur in the project area and that could be measurably affected by actions proposed in this Restoration Plan/FEIS include certain amphibians, reptiles, birds, mammals, aquatic invertebrates and zooplankton (see "Chapter 3 – Affected Environment"). The vertebrates will be presented first, followed by invertebrates.

The area of cumulative effect for this impact topic includes high elevation lands within the parks, YOSE, and Inyo, Sequoia, and Sierra National Forests. Note that both species of mountain yellow-legged frogs, Yosemite toad, Little Kern golden trout and Sierra Nevada bighorn sheep are evaluated as a separate impact topic under Special-Status Species.

Table 22. Wildlife Impact and Intensity Descriptions

Impact Intensity	Intensity Description
Negligible	There would be no observable or measurable impacts on native species, their habitats, or the natural processes sustaining them. Impacts would be well within natural fluctuations.
Minor	Impacts would be detectable but they would not be expected to be outside the natural range of variability of native species' populations, their habitats, or the natural processes sustaining them. Mitigation measures, if needed to offset adverse effects, would be simple and successful.
Moderate	Animals are present during particularly vulnerable life stages such as breeding, migration or early life stages; mortality or interference with activities necessary for survival could be expected on an occasional basis, but would not be expected to threaten the continued existence of the species in the park unit. Impacts on native species, their habitats, or the natural processes sustaining them would be detectable and could be outside the natural range of variability. Mitigation measures, if needed to offset adverse effects, would be extensive and likely successful.
Major	Impacts on native species, their habitats, or the natural processes sustaining them would be detectable and would be expected to be outside the natural range of variability. Key ecosystem processes might be disrupted. Loss of habitat might affect the viability of at least some native species. Extensive mitigation measures would be needed to offset any adverse effects and their success would not be guaranteed.

Short-term—recovers in less than 1 year.

Long-term—takes more than 1 year to recover.

VERTEBRATES

Impacts of Alternative A: No Action on Vertebrates

Under this alternative, nonnative fish removal would occur at 25 lakes and ponds and 3.7 mi (6.0 km) of connected stream habitat contained in seven basins (see Table 6 and Figure 5 in chapter 2), all of which were previously approved for treatment (NPS 2001, 2009A). No additional waterbodies would be treated. Nonnative fish are being removed using gill netting and electrofishing.

Extensive research has shown that nonnative trout have adverse effects on MYLFs (see chapter 1). Removing nonnative trout reverses these adverse effects and allows MYLF populations in treated areas to expand (Knapp et al. 2007, NPS 2012A). Removal of nonnative fish from the 25 treated waterbodies and 3.7 mi (6.0 km) of streams included in this alternative would therefore increase the number of MYLFs available as food sources to vertebrates known to feed on MYLFs, including the mountain garter snake, Sierra garter snake, Clark's nutcracker, Brewer's blackbird, American robin, northern water shrew, and coyote.

Research has also shown that nonnative trout have adverse effects on the Pacific treefrog (Matthews et al. 2002), and thus removal of nonnative fish from the 25 treated waterbodies and 3.7 mi (6.0 km) of streams included in this alternative should allow Pacific treefrog populations in treatment areas to expand. Increased numbers of Pacific treefrogs would provide additional food sources for native vertebrates that feed on frogs and tadpoles, including the mountain garter snake, Sierra garter snake, Clark's nutcracker, Brewer's blackbird, American robin, northern water shrew, and coyote.

Nonnative trout also have adverse effects on benthic invertebrate and zooplankton assemblages (Knapp et al. 2001, Knapp 2005, Knapp et al. 2005, Finlay and Vredenburg 2007), and thus removal of nonnative fish from the 10 ongoing waterbodies included in this alternative would allow aquatic invertebrate and zooplankton populations in treatment areas to expand. The increased number of aquatic invertebrates would provide additional food sources to vertebrates that feed on them, including the Pacific treefrog, mountain garter snake, Sierra garter snake, American dipper, spotted sandpiper, eared grebe, northern water shrew, gray-crowned rosy finch, Clark's nutcracker, Brewer's blackbird, American robin, and eight species of bats. In particular, the gray-crowned rosy finch has been shown to be more common in the high Sierra at fishless lakes versus fish-containing lakes, due to increased numbers of mayflies available as food at fishless lakes (Epanchin et al. 2010).

Although removal of nonnative trout from the 25 treated waterbodies and 3.7 mi (6.0 km) of streams (contained in seven basins) in this alternative would provide long-term beneficial effects to vertebrates in those locations, these waterbodies comprise 4% of the parks' 575 high elevation waterbodies known to contain self-sustaining populations of nonnative fish at the beginning of the treatment period.

In treated waterbodies, certain vertebrates sometimes get caught in gill nets. Depending on the length of time they have been caught before staff find and release them, individuals can be dead, released injured, or released with no visible injury. In the parks from 2001 to 2013, gill nets captured 94 non-target vertebrates (NPS 2015A), in addition to 205 MYLF captures (which are described in the Special-Status Species impact topic). Of the 94 vertebrate captures, 90 involved mortalities, 1 was released injured (an American dipper), and 3 were released with no visible injury (including 2 American dippers and 1 eared grebe). The 90 mortalities included 68 American dippers, 11 northern water shrews, 3 spotted sandpipers, 2 mountain garter snakes, 1 Pacific treefrog, 4our unknown birds, and 1 small unidentifiable native vertebrate. These 94 vertebrate captures represent 0.2% of all gill net captures through 2013 (40,606 nonnative fish + 205 MYLFs + 94 other vertebrates). The total gill net effort over the course of 13 years was 8,313,701 net hours during 17,161 different set-and-pull events. The 94 vertebrate captures therefore also represent a capture rate of 1.1 vertebrates for every 100,000 hours gill-netting; and the 90 vertebrate mortalities represent a mortality rate of 1.1 vertebrates for every 100,000 hours of gill-netting.

In treatment areas, vertebrates other than fish sometimes get stunned by electrofishing. In the parks from 2001 to 2013, amphibians were the only non-fish vertebrate to be stunned by electrofishing. Nearly all of the amphibians stunned were MYLFs (described in the special-status species impact topic); however, Pacific treefrogs were occasionally stunned. Amphibians typically hop or swim away as soon as the electrofishing field is stopped; rarely individuals need from several seconds to up to 2 minutes to recover before moving away from the work area. In the parks from 2001 to 2013, a total of 497 hours of electrofishing resulted in zero observed (non-fish) vertebrate mortalities (NPS 2015A).

Other vertebrates present in treatment areas and not captured by gill nets or caught in electrofishing fields sometimes exhibit a flight response during treatment activities, but the flight response would be no different than what would occur when visitors walk by these areas. These disturbances would be temporary in nature, and any individuals that took flight would typically resume their prior behaviors within a short amount of time.

At the same time, removal of nonnative fish in the parks from 2001 to 2013 appears to have resulted in increases in certain vertebrate populations in the treatment areas, presumably in response to increases in MYLF populations (NPS 2012A, 2015A). Several of the restored MYLF populations are now among the largest in the entire range of MYLFs, and the increased number of frogs has attracted vertebrates that feed on them, restoring the natural food web. In particular, mountain garter snakes were ten times more likely to be detected during shoreline surveys in lakes where fish were being removed (59 snakes detected over 421 surveys) versus lakes where fish were not removed (1 snake detected over 75 surveys; NPS 2015A). In addition, snake detections increased over time in two restoration areas. In upper Bubbs Creek, garter snake detections increased from less than one snake per five surveys in the first year of fish removal (2005) to more than one snake per two surveys 6 years later (NPS 2012A). Similarly, in upper LeConte Canyon, garter snake detections increased from 0 snakes per survey in the first year of fish removal (2001) to more than 3 snakes per 10 surveys 10 years later (NPS 2012A).

In addition, aquatic ecosystem restoration crews in the parks have documented the following observations that indicate other vertebrates are responding to increases in MYLFs in fish-removal areas. In upper LeConte Canyon, fish removal began in 2001 and MYLFs increased substantially by 2003, when a small flock of Brewer’s blackbirds was repeatedly observed capturing and feeding on MYLFs over the summer. In upper Bubbs Creek, fish removal began in 2005 and MYLFs increased substantially in one lake by 2011, when an American robin was observed repeatedly capturing and feeding on MYLFs. In this same lake in 2015, a northern water shrew was observed feeding on a MYLF tadpole. And between 2001 and 2011 in several fish-removal lakes in the parks, Clark nutcrackers were observed preying on MYLFs.

Aquatic ecosystem restoration crews in the parks have also observed the appearance of abundant mayfly hatches in several restoration lakes beginning 2 to 3 years after the onset of fish removal. While bird and bat population responses have not been measured, it is probable that gray-crowned rosy finches, which feed heavily on mayflies, as well as any of the eight bat species present in these areas during summer invertebrate hatches, have benefitted from this increased food source, as described in Epanchin et al. (2010).

Cumulative Effects –Alternative A - Vertebrates

The most substantial past action that has adversely affected vertebrates throughout the Sierra Nevada is nonnative fish stocking. Additional actions that could affect vertebrates when considering the additive impacts from alternative A include past, ongoing, and future aquatic ecosystem restoration projects outside the project area but within the area of cumulative effect (SEKI, YOSE, and Inyo, Sequoia, and Sierra National Forests). Effects from other park actions were evaluated under “Elements Common to All Alternatives.”

The past stocking and continued presence of native fish has altered the native food web and disrupted the type and distribution of species, and thus the natural function of the aquatic ecosystems across SEKI, and on adjacent lands. The continued presence of self-sustaining nonnative trout populations in the 550 waterbodies left untreated (contained in 88 basins) in SEKI would continue to adversely affect vertebrates through predation and competition for limited food sources in these low-productivity environments, resulting in a long-term major adverse effect on vertebrates. About 300 of these waterbodies are greater than 1 ha (2.5 ac) in surface area. Outside the parks in the area of cumulative effect, nonnative trout occupy about 2,000 lakes greater than 1 ha in surface area (Bahls 1992, Knapp 1996), an unknown number of ponds less than 1 ha (estimated in the thousands), plus connecting streams. The continued presence of nonnative trout in these waterbodies would also result in long-term major adverse effects on vertebrates. While this alternative would result in fewer waterbodies in the parks with nonnative fish species, it would not substantially contribute to the restoration of native ecosystems and native vertebrate populations, across the Sierra Nevada. The cumulative effects, if recovery efforts are successful, would be slight and beneficial both in the park and region-wide.

There are projects using gill netting and electrofishing to eradicate nonnative fish outside the parks that may result in short term slight adverse effects on vertebrates primarily from impacts associated with gill-netting, electrofishing, or disturbance from the presence of crews. There is the potential that these projects would also result in beneficial effects on vertebrates in the long term as native ecosystems are restored. In YOSE, eight waterbodies were approved in 2006 for experimental nonnative fish eradication; five been completed and three are in-progress (NPS unpublished data). Based on this success, up to 18 additional waterbodies were approved in 2012 for nonnative fish eradication (NPS 2012B; active restoration of MYLFs was also approved). In Inyo and Sierra NFs, nonnative fish have been eradicated or are in-progress toward eradication in 48 waterbodies (CDFW 2011). However, these projects are limited in scope and scale compared to the thousands of high elevation waterbodies that exist in the Sierra Nevada region. Only four of the vertebrates (spotted bat, western mastiff bat, small-footed myotis, and Yuma myotis) are considered to be sensitive species (see appendix F), and thus the remaining vertebrate populations are considered to be stable. Although the bat species are sensitive, no bats have ever been captured during gill netting activities in SEKI (NPS 2015A). Effects on vertebrates from these external projects would thus be localized and would not appreciably add to the short-term adverse effects in the project area under the no action alternative. Therefore, the no action alternative, when combined with similar actions outside the project area, would not significantly contribute to adverse cumulative effects on vertebrates.

The completion of nonnative fish eradication under the no action alternative would benefit vertebrates slightly. If the projects outside the parks described above are able to restore populations of frogs and invertebrates, then they would also benefit vertebrates. However, these projects are limited in scope and scale compared to the thousands of high elevation waterbodies that exist in the Sierra Nevada region. Effects on vertebrates from these external projects would thus be localized and would not appreciably add to the beneficial effects in the project area under the no action alternative. Therefore, the no action alternative, when combined with similar actions outside the project area, would not result in significant beneficial cumulative effects on vertebrates.

Conclusion: Overall, this alternative is expected to result in the following effects on vertebrates:

- *short-term moderate adverse effects* on American dippers, spotted sandpipers, eared grebes, northern water shrews, garter snakes, and Pacific treefrogs in 25 treatment waterbodies and 3.7 mi (6.0 km) of streams contained in seven basins, due to the potential for disturbance, injury or mortality to individuals from gill netting and electrofishing. This alternative would have substantially less short-term adverse effects on these vertebrates than alternative D, in which an additional 85 waterbodies and 31 mi (50 km) of streams contained in 21 basins would be treated using piscicides only. This alternative would also have substantially less short-term adverse effects on these vertebrates than alternative B, in which an additional 85 waterbodies and 31 mi (50 km) of streams contained in 21 basins would be treated, including 52 waterbodies and 15 mi (25 km) of streams contained in 17 basins using gill netting and electrofishing, and 33 waterbodies and 16 mi (25 km) of streams contained in 9 basins using piscicides. This alternative would have less short-term adverse effects on these vertebrates than alternative C, in which an additional 52 waterbodies and 15 mi (25 km) of streams contained in 17 basins would be treated using gill netting and electrofishing only;
- *slight long-term beneficial effects* on native vertebrates in 25 treatment waterbodies and 3.7 mi (6.0 km km) of streams contained in seven basins, due to: (1) increased natural food sources as existing MYLF, Pacific treefrog, and invertebrate populations increase to a larger size in response

to nonnative trout removal, and (2) the potential for extirpated MYLF populations to be reestablished in treated habitat. This alternative would have substantially less long-term beneficial effects on vertebrates than alternatives B and D, in which an additional 85 waterbodies and 31 mi (50 km) of streams contained in 21 basins would benefit from nonnative trout removal. This alternative would also have less long-term beneficial effects on vertebrates than alternative C, in which an additional 52 waterbodies and 15 mi (25 km) of streams contained in 17 basins would benefit from nonnative trout removal.

Cumulative effects on vertebrates would be slight, adverse and short term considering the numerous project activities underway across the parks and the region, and slight, long term and beneficial if the no action alternative results in the successful eradication of nonnative trout in the treatment areas.

Impacts from Elements Common to All Action Alternatives on Vertebrates

The following is the analyses of those elements common to all alternatives that could have an effect on the native vertebrates.

<u>Crew Camps:</u> Crew camps associated with this project are typically located in or near treatment areas. Crew camps would be located in upland areas away from water and thus away from core habitat for any aquatic vertebrates (Pacific treefrog, mountain garter snake, Sierra garter snake, American dipper, spotted sandpiper, eared grebe, and northern water shrew) that may be present in the project area. However, crew members walk to nearby water sources to collect buckets of water, and then walk the buckets back to camp for filtering drinking water and washing dishes. If aquatic vertebrates were present at a water collection area, this activity may sometimes cause individuals to exhibit a flight response, but the flight response would be no different than what would occur when visitors camp in these areas. These disturbances would be temporary in nature, and any individuals that took flight would typically resume their prior behaviors within a short amount of time.

Terrestrial vertebrates that could occasionally be present in or near crew camps include gray-crowned rosy finch, Clark's nutcracker, Brewer's blackbird, American robin and eight bat species, all of which fly and thus are highly mobile. Crew camp activity may sometimes cause individuals to exhibit a flight response, but the flight response would be no different than what would occur when visitors camp in these areas. These disturbances would be temporary in nature, and any individuals that took flight would typically resume their prior behaviors within a short amount of time.

Although coyotes could occasionally be present in project areas when crews are conducting fieldwork, it would be very unlikely for coyotes to come in or near crew camps during the day when crews are active. They could walk through crew camps during the night, which would be no different than walking through a visitor camp at night.

Conclusion: The use of crew camps would result in *short-term negligible adverse effects* on vertebrates.

<u>Helicopter and Stock Support:</u> Effects on vertebrates from the use of helicopters and stock to support the mobilization and demobilization of crew camps are expected to be similar to the effects from crew camps. Helicopter or stock would typically travel to and from crew camps in treatment areas twice each summer, and would typically be present during daylight hours for 30 minutes (helicopter) to 2 hours (stock) during each support trip.

Noise from helicopters landing and taking off near crew camps would be temporary and away from water - the core habitat of aquatic vertebrates. The use of helicopters is therefore expected to have no to negligible effects on Pacific treefrog, mountain garter snake, Sierra garter snake, American dipper, spotted sandpiper, eared grebe, and northern water shrew because helicopters would be landing and taking off outside of their habitat area. The use of helicopters could result in flight response by gray-crowned rosy finch, Clark's nutcracker, Brewer's blackbird, and American robin. However, all of these vertebrates are highly mobile and are expected to easily be able to leave the area while helicopters are landing and taking off. The eight bat species are not active during the day, and it is highly unlikely for coyotes to come in or near crew camps during the day. Therefore, the use of helicopters is expected to result in negligible short-term adverse effects on vertebrates.

Similarly, the presence of stock at crew camps would be temporary and mitigation would be utilized to keep stock away from water. Stock use is therefore expected to have a negligible effect on Pacific treefrog, mountain garter snake, Sierra garter snake, American dipper, spotted sandpiper, eared grebe, and northern water shrew because stock would be kept outside of their habitat area. In addition, stock are much less noisy than helicopters. Nevertheless, noise from stock use and the presence of stock animals could result in flight response by gray-crowned rosy finch, Clark's nutcracker, Brewer's blackbird, and American robin, but the flight response would be no different than what would occur when commercial, private or other administrative stock use may occur in these areas. These disturbances would be temporary in nature, and any individuals that took flight would typically resume their prior behaviors within a short amount of time.

The eight bat species are not active during the day, and it is highly unlikely for coyotes to come in or near crew camps during the day when crews are present and when stock use would occur. Therefore, the use of stock is expected to result in no to negligible short-term adverse effects on vertebrates.

Conclusion: Helicopter and stock support would result in *negligible short-term adverse effects* on vertebrates.

<u>Fish Disposal:</u> From 2001 to 2013, the parks removed 50,201 nonnative fish from 23 lakes, and sections of associated streams. Fish were sunk to the bottom of fish-removal lakes and occasionally sunk in fish-removal streams. Because physical fish removal slowly spreads out nutrient loading from fish decomposition over an extended period of time, this practice appears to have had no visible adverse effects on vertebrates, based on the crews never having observed any vertebrate mortality or algal blooms due to nutrient levels and related water chemistry during this time (NPS unpublished data).

In Rocky Mountain lakes, paleolimnological analyses indicated that algal production increased substantially following trout introductions and was maintained for the duration of fish presence. The results of modeling and paleolimnological analyses indicated that introduced trout fundamentally alter nutrient cycles and stimulate primary production by accessing benthic phosphorous sources that are not normally available to pelagic communities in oligotrophic mountain lakes (Schindler et al. 2001). This study shows that nutrient cycles have been altered since trout introductions to montane lakes, thus for many decades.

The sudden nutrient release from fish disposal may have a beneficial effect on some vertebrates by releasing critical nutrients to low-productivity ecosystems characteristic of the high Sierra. Increased nutrients may support increased levels of phytoplankton, which could support increased levels of benthic invertebrates and zooplankton (AFS 2000). It would be a limited period of time that nutrient levels (and any resulting algal growth) are elevated in these lakes from fish carcasses. Decomposition by benthic invertebrates mobilizes the nutrients into the food chain, probably within months. A study of a subalpine lake in Germany examining decomposition rates of fish carcasses by benthic macroinvertebrates found that total decomposition occurred between days 80 and 68 of the experiments (Premke et al. 2010). While lakes vary among ecosystems in their decomposition rates, the levels of algal growth observed in our treatment lakes during post-treatment monitoring of amphibians provide no evidence for concern. All of the vertebrates, except the coyote, consume invertebrates as a regular part of their diet and thus would benefit from any increase in invertebrate food (Knapp et al. 2001, Epanchin et al. 2010).

If any vertebrates are present near fish disposal activities, this activity may sometimes cause individuals to exhibit a flight response, but the flight response would be no different than what would occur when visitors walk by these areas. These disturbances would be temporary in nature, and any individuals that took flight would typically resume their prior behaviors within a short amount of time. In addition, coyotes have been documented by park crews to occasionally feed on fish carcasses in fish removal lakes (NPS 2012A), resulting in an increase in an unnatural food source (nonnative fish) available to this species during fish removal years.

Conclusion: Fish disposal is therefore expected to result in the following effects on vertebrates:

- *short- and long-term negligible adverse effects* on vertebrates due to changes in nutrient and water chemistry levels from elevated fish decomposition, and occasional fish carcasses available for consumption, during fish removal years;
- *short- and long-term beneficial effects* on Pacific treefrog, mountain garter snake, Sierra garter snake, American dipper, spotted sandpiper, eared grebe, northern water shrew, gray-crowned rosy finch, Clark’s nutcracker, Brewer’s blackbird, American robin, and eight bat species due to an increase in invertebrate food expected from nutrients released during fish decomposition.

<u>Restoration of Mountain Yellow-Legged Frogs:</u> Restoration of MYLFs involves human-assisted movement of a number of individuals from extant MYLF populations to other locations, in order to reestablish previously occupied habitat or augment dwindling populations. Vertebrates that may be present at source and recipient sites during the day include Pacific treefrog, mountain garter snake, Sierra garter snake, American dipper, spotted sandpiper, eared grebe, northern water shrew, gray-crowned rosy finch, Clark’s nutcracker, Brewer’s blackbird, and American robin, which are species more commonly seen in these habitats, and many of which have been documented to prey on MYLFs. For these vertebrates, capture and release activities may sometimes cause individuals to exhibit a flight response, but the flight response would be no different than what would occur when visitors walk by these areas. These disturbances would be temporary in nature, and any individuals that took flight would typically resume their prior behaviors within a short amount of time.

The eight species of bats that may occur in the project area are not active during the day and thus are not expected to be present at source and recipient sites while restoration activities are taking place. Similarly, coyote are not expected to be present during the day at source or recipient sites while crews are present.

The relocation of garter snakes away from MYLF reintroduction sites is expected to have a minor impact on local garter snake populations because it would be conducted on a very small, local scale (i.e., no more than 20 snakes in total would be relocated per year across the parks). While MYLFs are important to garter snakes in the high Sierra where they are a primary source of prey (Matthews et al. 2002), garter snakes are capable of a highly varied diet that includes other amphibians and their larvae (e.g., Pacific treefrogs; Jennings et al. 1992), fish, birds, mice, lizards, snakes, worms, leeches, slugs, and snails (Fitch 1941, Cunningham 1959, Arnold 1977, Kephart and Arnold 1982, Drummond and Burghardt 1983, Gregory et al. 1980, Britt et al. 2006). Garter snakes are also expected to have a large dispersal capability, moving large distances following spring emergence (Gregory and Stewart 1975, Larsen 1987) and covering large areas during active periods (Macartney et al. 1988). Given wide dispersal ability, preference for feeding on Pacific treefrogs that have limited susceptiblity to amphibian chytrid fungus (Reeder et al. 2012), and the relatively low number of snakes expected to need relocation from reintroduction areas, within basin garter snake relocations are not expected to negatively affect snake foraging success. Although garter snakes have experienced decline in parallel with MYLFs (Matthews et al. 2002), they have nevertheless persisted, likely due to their varied diet and dispersal capability.

While there has been success in moving garter snakes to new denning sites (MacMillan 1995, Takats 2002), snakes may experience some stress in their relocation habitat by having to acclimate to an unfamiliar site and search for new cover (Roe et al. 2010). Although some garter snakes show denning site fidelity (Macmillan 1995), garter snakes are anticipated to be capable of relocating their traditional hibernacula when moved within the same basin.

Although, snakes are expected to be able to persist in their relocated sites, this issue is planned for study from 2016 to 2018 in SEKI and YOSE. Results would be adaptively incorporated into this plan. Results are expected to help increase the likelihood of successful MYLF population establishment while reducing costs associated with failed reintroductions. Maximizing reintroduction success would not only increase the distribution of MYLF, but would also restore ecosystem functions lost as a result of MYLF extirpations. Over the long-term, relocated snakes may return to MYLF reintroduction sites. Overall, if recovery of MYLFs is aided by snake relocation, it would provide substantial benefits to snake populations across the recovery area.

The relocation of garter snakes from MYLF reintroduction sites is expected to have negligible effects on other vertebrate species via direct predation by garter snakes or via competition for the same prey as other vertebrates in question. Snake relocation would be conducted on a very small, local scale (i.e., no more than 20 snakes in total would be relocated per year across the parks) and would not have population-level effects on the Pacific treefrog, American dipper, spotted sandpiper, eared grebe, northern water shrew, gray-crowned rosy finch, Clark’s nutcracker, Brewer’s blackbird, or American robin.

While these actions may temporarily disturb individuals of certain vertebrates, any new populations of MYLFs established or dwindling populations augmented would provide additional food sources to native vertebrates known to feed on MYLFs, including mountain garter snake, Sierra garter snake, Clark’s nutcracker, Brewer’s blackbird, American robin, northern water shrew, and coyote.

Conclusion: Overall, active ecosystem restoration is expected to result in the following effects on vertebrates:

- *short-term negligible adverse effects* on Pacific treefrog, American dipper, spotted sandpiper, eared grebe, northern water shrew, gray-crowned rosy finch, Clark’s nutcracker, Brewer’s blackbird and American robin;
- *short-term minor adverse effects* on mountain garter snake and Sierra garter snake;
- *short- and long-term beneficial effects* on mountain garter snake, Sierra garter snake, Clark’s nutcracker, Brewer’s blackbird, American robin, northern water shrew, and coyote.

<u>Monitoring:</u> Ecosystem monitoring activities that occur in selected waterbodies in the project area and may affect vertebrates include conducting shoreline visual encounter surveys to monitor the presence and abundance of MYLFs and other herpetofaunal species, and occasionally placing scientific measuring devices such as small data loggers to periodically measure and record water temperature.

Vertebrates that may be present at monitoring sites during the day include Pacific treefrog, mountain garter snake, Sierra garter snake, American dipper, spotted sandpiper, eared grebe, northern water shrew, gray-crowned rosy finch, Clark’s nutcracker, Brewer’s blackbird, and American robin. For these vertebrates, monitoring activities may sometimes cause individuals to exhibit a flight response, but the flight response would be no different than what would occur when visitors walk by these areas. These disturbances would be temporary in nature, and any individuals that took flight would typically resume their prior behaviors within a short amount of time.

The eight species of bats that may occur in the project area are not active during the day and thus are not expected to be present at monitoring sites while activities are taking place. Similarly, coyotes are not expected to be present during the day at monitoring sites while crews are present.

While these actions may temporarily disturb individuals of certain vertebrates, the data generated are important for informing managers on the status of Pacific treefrog, mountain garter snake, and Sierra garter snake populations, determining whether intervention is needed to conserve them, and aid in monitoring the recovery of MYLFs which are an important food source to some of these native species.

Conclusion: Overall, monitoring is expected to result in the following effects on vertebrates:

- *short-term negligible adverse effects* on Pacific treefrog, mountain garter snake, Sierra garter snake, American dipper, spotted sandpiper, eared grebe, northern water shrew, gray-crowned rosy finch, Clark's nutcracker, Brewer's blackbird, and American robin;
- *long-term beneficial effects* on Pacific treefrog, mountain garter snake, and Sierra garter snake due to the acquisition of current status data that would allow managers to quickly intervene if necessary to conserve them.

<u>Continuing Research:</u> Continuing research activities expected to occur in selected waterbodies in the project area that may affect vertebrates include refining methods to: (1) bathe MYLFs in an anti-fungal solution to reduce amphibian chytrid levels on frog skin, (2) augment MYLF skin with beneficial, naturally occurring bacteria to increase natural protection from amphibian chytrid fungus, and (3) reestablish MYLF populations where they previously occurred or are dwindling toward extirpation due to amphibian chytrid fungus.

Vertebrates that may be present at research sites during the day include Pacific treefrog, mountain garter snake, Sierra garter snake, American dipper, spotted sandpiper, eared grebe, northern water shrew, gray-crowned rosy finch, Clark's nutcracker, Brewer's blackbird, and American robin. For these vertebrates, science activities may sometimes cause individuals to exhibit a flight response, but the flight response would be no different than what would occur when visitors walk by these areas. These disturbances would be temporary in nature, and any individuals that took flight would typically resume their prior behaviors within a short amount of time.

The eight species of bats that may occur in the project area are not active during the day and thus are not expected to be present at research sites while activities are taking place. Similarly, coyotes are not expected to be present during the day at research sites while crews are present.

While these actions may temporarily disturb individuals of certain vertebrate species, any populations of MYLFs that were assisted in surviving amphibian chytrid infection versus going extinct would preserve food sources for native vertebrates known to feed on MYLFs, including mountain garter snake, Sierra garter snake, Clark's nutcracker, Brewer's blackbird, American robin, northern water shrew, and coyote.

Conclusion: Overall, continued research is expected to result in the following effects on vertebrates:

- *short-term negligible adverse effects* on Pacific treefrog, mountain garter snake, Sierra garter snake, American dipper, spotted sandpiper, eared grebe, northern water shrew, gray-crowned rosy finch, Clark's nutcracker, Brewer's blackbird, and American robin;
- *short- and long-term beneficial effects* on mountain garter snake, Sierra garter snake, Clark's nutcracker, Brewer's blackbird, American robin, northern water shrew, and coyote.

Cumulative Effects from Elements Common to All Action Alternatives on Vertebrates

The past, ongoing, and foreseeable future project activities within SEKI and in the Sierra Nevada region that could result in additive impacts on vertebrates include the past stocking of nonnative fish, the establishment and / or continued use of crew camps for general resource management, science, and maintenance activities, the use of helicopters and stock, and trail maintenance work.

As discussed in alternative A, the past stocking and continued presence of native fish has altered the native food web and disrupted the type and distribution of species, and thus the natural function of the aquatic ecosystems across SEKI, and on adjacent lands. The impacts associated with the elements common to all action alternatives would result in slight or negligible adverse effects on vertebrates, but would not alter the type and distribution of species, and would not substantially contribute to the adverse effects that occurred as a result of this past action. Therefore the cumulative effects from this project work would be insignificant when compared with these past actions.

The impacts from crew camps and trail work result primarily from disturbance associated with noise, habitat disturbance that occurs around trail corridors, and the presence of crews causing flight response. The level of impact, however, associated with these activities is small because crews are generally small, there is ample high quality and escape habitat available nearby, the impacts are localized and the duration of activities is temporary. Thus, these impacts would not substantially contribute to the overall cumulative effects.

The use of helicopter and stock for resources and science, trail work, and emergency actions, when combined with similar activities under Elements Common to All Alternatives, would result in a slight potential for adverse effects on vertebrates around flight corridors and landing zones, but these activities would not substantially contribute to the cumulative effects.

Impacts of Alternative B: Prescription Treatment Preceding Restoration (Preferred Alternative) on Vertebrates

Under this alternative, nonnative fish would be removed from an additional 85 waterbodies (31 lakes, 49 ponds, 5 associated marshes) and approximately 31 mi (50 km) of connected stream habitat contained in 21 basins (see Table 9, Table 10 and Table 11 and Figure 7 in chapter 2). Nonnative fish would be removed using physical methods (gill netting and electrofishing) from 52 waterbodies (27 lakes, 24 ponds, 1 marsh) and approximately 15 mi (25 km) of streams contained in 17 basins. Nonnative fish would be removed using piscicides (rotenone) from 33 waterbodies (4 lakes, 25 ponds, 4 marshes) and approximately 16 mi (25 km) of streams contained in 9 basins. Nonnative fish would be eradicated from an additional 85 waterbodies and 31 mi (50 km) of streams, substantially reducing the overall impact on vertebrates.

Removal of nonnative fish from the additional 85 treatment waterbodies and 31 mi (50 km) of streams included in this alternative would substantially increase the number of MYLFs and Pacific treefrogs available as food sources to vertebrates known to feed on them, including the mountain garter snake, Sierra garter snake, Clark’s nutcracker, Brewer’s blackbird, American robin, northern water shrew, and coyote.

Similarly, removal of nonnative fish from the additional 85 treatment waterbodies and 31 mi (50 km) of streams included in this alternative would substantially increase the number of benthic invertebrates available as food sources to vertebrates known to feed on them, including the Pacific treefrog, mountain garter snake, Sierra garter snake, American dipper, northern water shrew, gray-crowned rosy finch, Clark’s nutcracker, Brewer’s blackbird, American robin, spotted sandpiper, eared grebe, and eight species of bats.

These 85 waterbodies comprise 15% of the parks' 550 high elevation waterbodies that will contain nonnative fish after completion of the ongoing (previously approved) fish removal sites described in alternative A (no action). The continued presence of self-sustaining nonnative trout populations in the 465 waterbodies left untreated (contained in 69 basins) would continue to adversely affect vertebrates through predation and competition for limited food sources in these low-productivity environments.

Effects on vertebrates due to gill netting, electrofishing and crew activities would be the same as described under alternative A (no action), although gill netting and electrofishing would occur at an additional 52 waterbodies and approximately 15 mi (25 km) of streams, and crew activities would occur at an additional 85 waterbodies and 31 mi (50 km) of streams.

Effects on 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, the "capture-and-move" mitigation as described in Special-status Species, would be implemented to 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. Although treefrog population numbers would likely be low due to fish predation, if large numbers could be moved they would divided among nearby fishless habitats to minimize potential for density-dependent effects in recipient habitats.

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 0.5 to 1.0 ppm (=25 to 50 ppb rotenone) in streams and 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 0.5 to 1.0 ppm (=25 to 50 ppb rotenone) in streams and 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 (Billman et al. 2012), 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 would 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 2015A). 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 R., unpublished data) 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 would decompose in deep water and thus not be available for consumption by birds, a small number of treated fish that do not sink and are missed by project personnel 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 these bird species may potentially consume in comparison to the large amount of fish tissue birds would need to eat for there to be any potential for an observable effect. 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 al. 2001, Knapp et al. 2005), so the effect is expected to be negligible. In addition, all of the treatment areas have nearby lakes and streams that would not be treated, and thus invertebrate food would 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 et al. 2005, Hamilton et al. 2009), which would have long-term beneficial effect on the bird species.

Piscicide treatments are therefore expected to have short-term negligible adverse effects on birds and long-term beneficial effects.

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.

Nevertheless, since the northern water shrew is highly aquatic, potential effects from rotenone exposure are provided here. Although no studies are known to have examined rotenone toxicity to shrews, there are studies of rotenone toxicity to the white mouse (a.k.a. house mouse, *Mus musculus*). Kidd and James (1991) report a median lethal dose of rotenone of 350 mg/kg for the house mouse. The average weight of the house mouse is 20 g (Berry 1970), which is similar in size to the northern water shrew with an average weight of 15 g (Gusztak and Campbell 2004). The northern water shrew also has a daily intake of 0.95 g/g/day (grams of food per gram of body weight per day; Sorenson 1962).

A 15 g northern water shrew would have an estimated daily food intake of 14.3 g (15 g × 0.95 g/g/day), and would thus receive 3.2 µg of rotenone if it foraged its entire daily ration from trout in a treatment area [(14.3 g ÷ 76 g) × 17 µg]. This 3.2 µg of rotenone is far below the median lethal dose of rotenone of 5,250 µg of rotenone for similarly sized mammals (350 mg/kg × 0.015 kg shrew = 5.25 mg = 5,250 µg). Piscicide treatments are therefore expected to have negligible effects on northern water shrews.

Although coyotes are known to occur in the project area, restoration crews in the parks from 2001 to 2013 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.

Nevertheless, since the coyote is thought to occasionally feed on fish, potential effects from rotenone exposure are provided here. Although no studies are known to have examined rotenone toxicity to coyotes, there are studies of rotenone toxicity to the domestic dog, some breeds of which are similar in size to coyotes. Marking (1988) reported a no observed effect level (NOEL) of 0.4 mg/kg of rotenone for beagles. Female coyotes outside the northeastern U.S. have the lowest body mass of all North American coyotes, with an average mass of 10.6 kg (Way 2007). This mass was used in our rotenone toxicity calculations to provide a more conservative approximation of rotenone toxicity to coyotes. Estimated daily intake for coyotes is approximately 30 g/kg/day (grams of food per kilogram of body weight per day; Litvaitis and Mautz 1980).

A 10.6 kg coyote would have an average daily food intake of 318 g (10.6 kg × 30 g/kg/day) and would receive 71.1 µg of rotenone if it foraged its entire daily ration from trout in a treatment area [(318 g ÷ 76 g) × 17 µg]. This 71.1 µg of rotenone is far below (1.7%) the NOEL for rotenone of 4,240 µg for similarly sized mammals (0.4 mg/kg × 10.6 kg coyote = 4.24 mg = 4,240 µg). Put another way, an average-sized coyote would need to consume nearly 250 average-sized trout in a rotenone treatment area to even reach the NOEL (4,240 µg ÷ 17 µg). Therefore, piscicide treatments are expected to have negligible effects on coyotes.

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.

Piscicide treatments are therefore expected to have short-term negligible to minor adverse effects and long-term beneficial effects on mammals.

Cumulative Effects– Alternative B – Vertebrates

Specifically, for vertebrates, the past, ongoing and foreseeable future actions within SEKI and in the Sierra Nevada region that could result in additive impacts on vertebrates include the past stocking of nonnative fish, ongoing restoration projects, and park administration activities (e.g. resource management, science, and trail maintenance projects).

As discussed in alternative A, the past stocking and continued presence of native fish has altered the native food web and disrupted the type and distribution of species, and thus the natural function of the aquatic ecosystems across SEKI, and on adjacent lands. Self-sustaining nonnative trout populations would remain in 465 additional lakes, ponds, and marshes known to contain fish, plus hundreds of miles of connected stream habitat. Effects on vertebrates due to nonnative fish and active restoration of MYLFs would be the same as described under alternative A (no action). Under alternative B, the continued presence of self-sustaining nonnative trout populations as a result of past stocking actions would continue to adversely affect native vertebrates in about 2,000 lakes, ponds, and connecting streams in the Sierra Nevada region. While this alternative would result in fewer waterbodies in the parks with nonnative fish species, and it would benefit vertebrate species and native ecosystems within the parks, it would not substantially contribute to the restoration of native ecosystems and native vertebrate populations across the Sierra Nevada. The cumulative effects, if recovery efforts are successful, would be important and beneficial within the parks, and slight and beneficial region-wide.

Short-term adverse effects on vertebrates from projects using gill netting and electrofishing outside the parks in the area of cumulative effect are the same as described under the no action alternative. In summary, these activities would not appreciably add to the short-term adverse effects to vertebrates when combined with the effects from alternative B.

Because the scope and scale of this alternative is large, it would result in long-term beneficial effects on vertebrates when combined with the projects outside the parks described previously. However, because there are thousands of high elevation waterbodies that exist in the Sierra Nevada region, alternative B would not contribute substantially to the overall beneficial cumulative effect on vertebrates, though it would be more beneficial than alternative A.

Conclusion: Overall, this alternative is expected to result in the following effects on vertebrates:

- *short-term moderate adverse effects* on native vertebrates in an additional 85 treatment waterbodies and 31 mi (50 km) of streams in 21 basins due to the potential for disturbance, injury or mortality to individuals from gill netting and electrofishing in 52 waterbodies and 15 mi (25 km) of streams contained in 17 basins, and from piscicides in 33 waterbodies and 16 mi (25 km) of streams contained in 9 basins. This alternative would have less short-term adverse effects on vertebrates than alternative D, in which an additional 85 waterbodies and 31 mi (50 km) of streams contained in 21 basins would be treated using piscicides only. This alternative would have more short-term adverse effects on vertebrates than alternative C, in which an additional 52 waterbodies and 15 mi (25 km) of streams contained in 17 basins would be treated using gill netting and electrofishing only. This alternative would have substantially more short-term adverse effects on vertebrates than alternative A, in which no additional waterbodies would be treated;
- *substantial long-term beneficial effects* on native vertebrates in an additional 85 treatment waterbodies and 31 mi (50 km) of streams contained in 21 basins, due to: (1) increased natural food sources as existing MYLF, Pacific treefrog, and invertebrate populations increase to a larger size in response to nonnative trout removal, and (2) the potential for extirpated MYLF populations to be reestablished in treated habitat. This alternative would have the same long-term beneficial effects on vertebrates as alternative D, in which an additional 85 waterbodies and 31 mi (50 km) of streams contained in 21 basins would benefit from nonnative trout removal. This alternative would have more long-term beneficial effects on vertebrates than alternative C, in which an additional 52 waterbodies and 15 mi (25 km) of streams contained in 17 basins would benefit from nonnative trout removal. This alternative would have substantially more long-term beneficial effects on vertebrates than alternative A, in which no additional waterbodies would benefit from nonnative trout removal.

Cumulative effects on vertebrates would be slight, adverse and short term considering the numerous project activities underway across the parks and the region, and slight to substantial, long term and beneficial if alternative B results in the successful eradication of nonnative trout in the treatment areas.

Impacts of Alternative C: Physical Treatment Preceding Restoration on Vertebrates

Under this alternative, nonnative fish would be removed from 52 additional waterbodies (27 lakes, 24 ponds, 1 marsh) and approximately 15 mi (25 km) of connected stream habitat contained in 17 basins (see Table 9 and Table 14, and Figure 9 in chapter 2). Nonnative fish would be removed using physical methods only (gill netting and electrofishing). Blasting rock to create vertical fish barriers in these physical treatment areas would be conducted (if determined necessary) at up to five natural cascades.

Nonnative fish would be eradicated from an additional 52 waterbodies and 15 mi (25 km) of streams (when compared with no action) reducing the overall impact on vertebrates.

Removal of nonnative fish from the additional 52 treatment waterbodies and 15 mi (25 km) of streams included in this alternative would increase the number of MYLFs and Pacific treefrogs available as food sources to vertebrates known to feed on amphibians, including the mountain garter snake, Sierra garter snake, Clark's nutcracker, Brewer's blackbird, American robin, northern water shrew, and coyote.

Similarly, removal of nonnative fish from the additional 52 treatment waterbodies and 15 mi (25 km) of streams included in this alternative would increase the number of benthic invertebrates available as food sources to vertebrates known to feed on them, including the Pacific treefrog, mountain garter snake, Sierra garter snake, American dipper, northern water shrew, gray-crowned rosy finch, Clark's nutcracker, Brewer's blackbird, American robin, spotted sandpiper, eared grebe, and eight species of bats.

These 52 waterbodies comprise 9% of the parks' 550 high elevation waters that will contain nonnative fish after completion of the ongoing (previously approved) fish removal sites described in alternative A (no action). The continued presence of self-sustaining nonnative trout populations in the 498 waterbodies left untreated (contained in 80 basins) would continue to adversely affect vertebrates through predation and competition for limited food sources in these low-productivity environments.

Effects on vertebrates due to gill netting, electrofishing and crew activities would be the same as described under alternative A (no action), although these activities would take place at an additional 52 waterbodies and 15 mi (25 km) of streams contained in 17 basins.

Effects on vertebrates due to blasting rock, if determined necessary to create vertical fish barriers, include the following. First, it is estimated that blasting may be necessary at no more than five natural cascades over the duration of the project. Second, blasting would occur in late summer when streams are at their lowest flows of the season. Third, Pacific treefrog tadpoles are unlikely be present in blasting areas because cascades are too steep to have pools present as habitat for tadpoles. Any birds or mammals present as crews begin work would exhibit a flight response, but these disturbances would be temporary in nature, and any individuals that took flight would typically resume their prior behaviors in a distant location within a short amount of time. The same would apply to garter snakes and Pacific treefrog adults and juveniles; however, there is slight potential for individuals of these species to seek cover within the immediate work area rather than exhibiting a flight response out of the work area. If this occurred, there would be potential for those individuals to be injured or killed during a blast, either from the force of the blast or by rock projectiles. Any injury or mortality to individual snakes or treefrogs from blasting would have negligible effects on the local populations of those species. In the long-term, blasting rock to create vertical fish barriers would allow certain treatment areas to be fully eradicated of trout, which would result in long-term beneficial effects on vertebrates.

Cumulative Effects– Alternative C – Vertebrates

The cumulative effects on vertebrates under alternative C are similar to those described under alternatives A and B. Under alternative C, 33 fewer waterbodies and 16 fewer miles of streams would be eradicated of nonnative fish, no piscicides would be used, and blasting would be used if determined necessary at up to five cascades. Self-sustaining nonnative trout populations would remain in 498 lakes, ponds, and marshes in SEKI known to contain fish, plus hundreds of miles of adjacent stream habitat. Cumulative effects on vertebrates due to nonnative fish and active restoration of MYLFs would be the same as described under alternative A (no action).

Projects using gill netting and electrofishing outside the parks would result in the same cumulative effects on vertebrates as described under the no action alternative. There would be long-term beneficial effects on vertebrates when combined with the other ecosystem restoration projects outside the parks, however this alternative would not contribute substantially to the overall beneficial effects on vertebrates because it is limited in scope and scale, though it would be more beneficial than alternative A. While this alternative would result in fewer waterbodies in the parks with nonnative fish species, and it would benefit vertebrate species and native ecosystems within the parks, it would not substantially contribute to the restoration of native ecosystems and native vertebrate populations across the Sierra Nevada. The cumulative effects, if recovery efforts are successful, would be important and beneficial within the parks, and slight and beneficial region-wide.

Trail maintenance projects routinely use blasting in terrestrial areas but do not blast in streams in rivers. These actions are limited in scope and scale, occurring in a few small areas per year resulting in slight localized and temporary adverse effects on vertebrates, primarily from flight response and habitat disturbance or removal. Effects on vertebrates from trail blasting projects outside the project area would thus be localized and would not appreciably add to the short-term adverse effects on vertebrates when combined with the effects from alternative C. There would be no discernable adverse cumulative effects on vertebrates from blasting actions.

Conclusion: Overall, this alternative is expected to result in the following effects on vertebrates:

- *short-term moderate adverse effects* on native vertebrates in an additional 52 treatment waterbodies and 15 mi (25 km) of streams in 17 basins due to the potential for disturbance, injury, or mortality to individuals from gill netting and electrofishing, and from blasting (if necessary) in up to 5 locations. This alternative would have substantially less short-term adverse effects on vertebrates than alternative D, in which an additional 85 waterbodies and 31 mi (50 km) of streams contained in 21 basins would be treated using piscicides only. This alternative would have less short-term adverse effects on vertebrates than alternative B, in which an additional 85 waterbodies and 31 mi (50 km) of streams contained in 21 basins would be treated, including 52 waterbodies and 15 mi (25 km) of streams contained in 17 basins using gill netting and electrofishing, and 33 waterbodies and 16 mi (25 km) of streams contained in 9 basins using piscicides. This alternative would have more short-term adverse effects on vertebrates than alternative A (no action), in which no additional waterbodies would be treated;
- long-term beneficial effects on native vertebrates in an additional 52 treatment waterbodies and 15 mi (25 km) of streams contained in 17 basins, due to (1) increased natural food sources as existing MYLF, Pacific treefrog and invertebrate populations increase to a larger size in response to nonnative trout removal, and (2) the potential for extirpated MYLF populations to be reestablished in treated habitat. This alternative would have less long-term beneficial effects on vertebrates than alternatives B and D, in which an additional 85 waterbodies and 31 mi (50 km) of streams contained in 21 basins would benefit from nonnative trout removal. This alternative would have more long-term beneficial effects on vertebrates than alternative A, in which no additional waterbodies would benefit from nonnative trout removal.

Cumulative effects on vertebrates would be slight, adverse and short term considering the numerous project activities underway across the parks and the region, and slight to substantial, long term and beneficial if alternative C results in the successful eradication of nonnative trout in the treatment areas.

Impacts of Alternative D: Piscicide Treatment Preceding Restoration on Vertebrates

Under this alternative, nonnative fish would be removed from an additional 85 waterbodies (31 lakes, 49 ponds, 5 associated marshes) and approximately 31 mi (50 km) of connected stream habitat contained in 21 basins (see Table 9 and Table 15, and Figure 10 in chapter 2). Nonnative fish would be removed using piscicides only (rotenone).

Effects on vertebrates due to nonnative fish and active restoration of MYLFs would be the same as described under alternative A (no action), although nonnative fish would be eradicated from an additional 85 waterbodies and 31 mi (50 km) of streams contained in 21 basins, substantially reducing the overall impact on vertebrates.

Removal of nonnative fish from the additional 85 treatment waterbodies and 31 mi (50 km) of streams included in this alternative would substantially increase the number of MYLFs and Pacific treefrogs available as food sources to vertebrates known to feed on them, including the mountain garter snake, Sierra garter snake, Clark’s nutcracker, Brewer’s blackbird, American robin, northern water shrew, and coyote.

Similarly, removal of nonnative fish from the additional 85 treatment waterbodies and 31 mi (50 km) of streams included in this alternative would substantially increase the number of benthic invertebrates available as food sources to vertebrates known to feed on them, including the Pacific treefrog, mountain garter snake, Sierra garter snake, American dipper, northern water shrew, gray-crowned rosy finch, Clark’s nutcracker, Brewer’s blackbird, American robin, spotted sandpiper, eared grebe, and eight species of bats.

Effects on vertebrates due to crew activities would be the same as described under alternative A (no action), although crews would be active at an additional 85 waterbodies. Effects on vertebrates due to piscicide use would be the same as described under alternative B, although piscicides would be used in 52 more waterbodies.

Cumulative Effects – Alternative D – Vertebrates

The cumulative effects on vertebrates under alternative D are similar to those described under alternative B, except that 52 more waterbodies and 15 more miles (25 km) of streams would be eradicated of nonnative fish using piscicides, and no gill netting, electrofishing or blasting would be used. The continued presence of self-sustaining nonnative trout populations in the 465 waterbodies left untreated (contained in 69 basins) would continue to adversely affect vertebrates through predation and competition for limited food sources in these low-productivity environments.

Conclusion: Overall, this alternative is expected to result in the following effects on vertebrates:

- *short-term moderate adverse effects* on native vertebrates in an additional 85 treatment waterbodies and 31 mi (50 km) of streams contained in 21 basins, due to the potential for disturbance, injury or mortality to individuals from piscicide use. This alternative would have more short-term adverse effects on vertebrates than alternative B, in which an additional 52 waterbodies and 15 mi (25 km) of streams contained in 17 basins would be treated using gill netting and electrofishing, and an additional 33 waterbodies and 16 mi (25 km) of streams contained in 9 basins would be treated using piscicides. This alternative would have more short-term adverse effects on vertebrates than alternative C, in which an additional 52 waterbodies and 15 mi (25 km) of streams contained in 17 basins would be treated using gill netting and electrofishing. This alternative would have substantially more short-term adverse effects on vertebrates than alternative A, in which no additional waterbodies would be treated;
- *substantial long-term beneficial effects* on native vertebrates in an additional 85 treatment waterbodies and 31 mi (50 km) of streams contained in 21 basins, due to (1) increased natural food sources as existing MYLF, Pacific treefrog and invertebrate populations increase to a larger size in response to nonnative trout removal, and (2) the potential for extirpated MYLF populations to be reestablished in treated habitat. This alternative would have the same long-term beneficial effects on vertebrates as alternative B. This alternative would have more long-term beneficial effects on vertebrates than alternative C, in which an additional 52 waterbodies and 15

mi (25 km) of streams contained in 17 basins would benefit from nonnative trout removal. This alternative would have substantially more long-term beneficial effects on vertebrates than alternative A, in which no additional waterbodies would benefit from nonnative trout removal.

Cumulative effects on vertebrates would be slight, adverse and short term considering the numerous project activities underway across the parks and the region, and slight to substantial, long term and beneficial if alternative D results in the successful eradication of nonnative trout in the treatment areas.

INVERTEBRATES

The analysis of project effects on invertebrates is focused on invertebrates known to occur in the project area and that use water as habitat for all or most of their life cycles (benthic and pelagic macroinvertebrate and zooplankton species, hereafter referred to as "aquatic invertebrates" and "zooplankton," respectively). These organisms would receive the bulk of effects caused by project actions. Effects on terrestrial invertebrates would also occur, although to a more limited extent as compared to aquatic invertebrates and zooplankton. Nevertheless, project effects on terrestrial invertebrates in the project area are also included in this analysis.

Impacts of Alternative A: No Action on Invertebrates

Under this alternative, nonnative fish removal would be limited to 25 treatment lakes and ponds and 3.7 mi (6.0 km) of connected stream habitat contained in seven basins (see Table 6 and Figure 5 in chapter 2), all of which were previously approved for treatment (NPS 2001, 2009A). Nonnative fish are being removed using physical methods only, including gill netting and electrofishing. Self-sustaining nonnative trout populations would remain in 550 additional lakes, ponds, and marshes known to contain fish, plus hundreds of miles of connected stream habitat.

Extensive research has shown that nonnative trout have direct adverse effects on aquatic invertebrate and zooplankton assemblages due to predation and competition (see chapter 1). Removal of nonnative trout from the 25 treated waterbodies and 3.7 mi (6.0 km) of streams included in this alternative would allow aquatic invertebrate and zooplankton populations in treated areas to expand, thereby increasing the abundance, distribution and diversity of these assemblages.

Extensive research has also shown that nonnative trout have adverse effects on MYLFs (see chapter 1), and thus indirect adverse effects on aquatic invertebrate and zooplankton assemblages. MYLFs, aquatic invertebrates, and zooplankton developed together in high Sierra aquatic ecosystems, and thus are naturally adapted to each other. Juvenile and adult frogs regulate invertebrate levels through predation; tadpoles cycle nutrients through algal grazing and waste excretion; and both tadpoles and frogs are prey to predatory invertebrates such as Dytiscid beetle larvae. Removing nonnative trout allows MYLF populations in treatment areas to expand (Knapp et al. 2007, NPS 2012A), and also allows native benthic macroinvertebrates the ability to recover (Knapp et al. 2001). Removal of nonnative fish from the 10 treated waterbodies included in this alternative would therefore increase the number of MYLFs available to provide benefits to ecosystem processes and native species including invertebrates (Finlay and Vredenburg 2007).

The removal of nonnative trout from the 25 treated waterbodies and 3.7 mi (6.0 km) of streams included in this alternative would provide long-term beneficial effects to invertebrates in those locations. These waterbodies comprise 4% of the parks' 575 high elevation water known to contain nonnative trout at the beginning of the treatment period.

In lake treatment areas, effects on the invertebrates due to gill-netting include the following. Individual aquatic invertebrates and zooplankton are too small to get caught in the mesh portions of gill nets used in this project, which are designed to catch trout of various sizes. However, individuals may sometimes rest on nets and remain on them as they are removed from water for repair or over-winter storage. Although such individuals could be injured or perish before the nets are re-deployed in water, it would be expected to result in little effect on their respective populations.

Since trout eradication by gill-netting involves crews repeatedly setting and pulling nets using float tubes, wearing flip fins and stepping in shallow water to enter and exit float tubes, some aquatic invertebrates and zooplankton may be inadvertently trampled by gill net crews. Although such individuals could be injured or perish, it would be expected to result in little effect on their respective populations.

Invertebrates present in treated areas, but not affected by gill-net removal or crew trampling, could sometimes exhibit a flight response during treatment activities. These disturbances would be temporary in nature, and any individuals that took flight would typically resume their prior behaviors within a short amount of time.

In stream treatment areas, aquatic invertebrates sometimes get stunned by electrofishing. However, because the output from electrofishers is engineered to specifically stun fish, non-target organisms are much less affected by electrofishing. For example, although some aquatic invertebrates are induced to drift in the water column when caught in an electrofishing field (Elliot and Bagenal 1972, Fowles 1975, Bisson 1976), they tend to immediately return to the substrate once they drift out of the electrofishing field (NPS unpublished observations). Furthering this observation, Mesick and Tash (1980) and Brown et al. (2000) measured no negative effects due to electrofishing current on populations of aquatic invertebrates. Moreover, Kulp and Moore (2000) found that fish removal by repeated electrofishing exhibited no negative effects on populations of rainbow trout in a control stream. Since rainbow trout are insectivorous, this suggests that the aquatic invertebrate assemblage was also not impacted by electrofishing.

In the parks from 2001 to 2013, invertebrates were sometimes observed drifting in electrofishing fields and occasionally landing in dipnets (NPS unpublished data). Nearly all of the invertebrates observed were larval stonefly and mayfly individuals. These invertebrates typically swam away as soon as the electrofishing field was stopped; rarely individuals need a few seconds to recover before swimming away from the electrofishing area. Individuals that land in dipnets are returned to the stream as crews periodically turn their dipnets inside out and rinse in water. In the parks from 2001 to 2013, a total of 497 hours of electrofishing resulted in zero observed invertebrate mortalities (NPS 2015A).

Since trout eradication by electrofishing involves repeating wading of treated streams by the electrofisher operator and 1 to 2 dipnetters, some aquatic invertebrates may be inadvertently trampled by field crews. Although such individuals could be injured or perish, it would be expected to result in little effect on their respective populations.

Invertebrates present in treated areas, but not affected by electrofishing fields or wading crews, would sometimes exhibit a flight response during treatment activities, but the flight response would be no different than what would occur when visitors walk by these areas. These disturbances would be temporary in nature, and any individuals that took flight would typically resume their prior behaviors within a short amount of time.

At the same time, removal of nonnative fish in the parks from 2001 to 2013 appears to have resulted in increases in certain invertebrate populations in the treatment areas, presumably in response to elimination of fish predation. Restoration crews in the parks have observed the appearance of abundant mayfly hatches in several restoration lakes beginning 2 to 3 years after the onset of fish removal (NPS unpublished data). Abundant mayfly hatches are thus expected to become a common annual occurrence at most trout removal lakes, with corresponding beneficial effects to these ecosystems in the form of increased food sources and nutrient cycling.

Cumulative Effects – Alternative A - Invertebrates

The most substantial past action that has adversely affected invertebrates throughout the Sierra Nevada is nonnative fish stocking. Additional actions that could affect vertebrates when considering the additive impacts from alternative A include past, ongoing, and future aquatic ecosystem restoration projects outside the project area but within the area of cumulative effect (SEKI, YOSE, and Inyo, Sequoia, and Sierra National Forests). Effects from other park actions were evaluated under "Elements Common to All Alternatives."

Under alternative A, the continued presence of self-sustaining nonnative trout populations in 550 untreated waterbodies plus connecting streams in the parks would continue to have a long-term major adverse effect on invertebrates. The continued presence of self-sustaining nonnative trout populations in the 550 waterbodies left untreated (contained in 88 basins) would continue to adversely affect the invertebrates through predation and competition for limited food sources in these low-productivity environments. About 300 of these waterbodies are greater than 1 ha (2.5 ac) in surface area. Outside the parks in the area of cumulative effect, nonnative trout occupy about 2,000 lakes greater than 1 ha in surface area (Bahls 1992, Knapp 1996), an unknown number of ponds less than 1 ha (estimated in the thousands), plus connecting streams. The continued presence of nonnative trout in these waterbodies would also result in long-term major adverse effects on invertebrates. While this alternative would result in fewer waterbodies in the parks with nonnative fish species, it would not substantially contribute to the restoration of native ecosystems and native invertebrate populations, across the Sierra Nevada. The cumulative effects, if recovery efforts are successful, would be slight and beneficial both in the park and region-wide.

There are projects using gill netting and electrofishing to eradicate nonnative fish outside the parks that may result in short-term negligible to minor adverse effects to invertebrates and long-term beneficial effects. In YOSE, eight waterbodies were approved in 2006 for experimental nonnative fish eradication; five been completed and three are in-progress (NPS unpublished data). Based on this success, up to 18 additional waterbodies were approved in 2012 for nonnative fish eradication (NPS 2012B; active restoration of MYLFs was also approved). In Inyo NF, nonnative fish have been eradicated from 23 waterbodies; and in Sierra NF, nonnative fish have been eradicated from 5 waterbodies (CDFW unpublished data). A small number of additional waterbodies are in-progress in these national forest areas. However, these projects outside the parks are limited in scope and scale compared to the thousands of high elevation waterbodies that exist in the area of cumulative effect. Effects on invertebrates from these external projects would thus be localized and would not appreciably add to the short or long-term adverse and beneficial effects in the project area under the no action alternative. Therefore, the no action alternative, when combined with similar actions outside the parks, would not result in significant beneficial or adverse cumulative effects on invertebrates.

Conclusion: Overall, this alternative is expected to result in the following effects on invertebrates:

- *short-term negligible to minor adverse effects* on invertebrates due to the potential for disturbance, injury or mortality to individuals from gill netting and electrofishing activities in 25 treated waterbodies and 3.7 mi (6.0 km) of streams contained in seven basins. This alternative would have substantially less short-term adverse effects on invertebrates than alternative D, in which an additional 85 waterbodies and 31 mi (50 km) of streams contained in 21 basins would be treated using piscicides only. This alternative would also have substantially less short-term adverse effects invertebrates than alternative B, in which an additional 85 waterbodies and 31 mi (50 km) of streams contained in 21 basins would be treated, including 52 waterbodies and 15 mi (25 km) of streams contained in 17 basins using gill netting and electrofishing, and 33 waterbodies and 16 mi (25 km) of streams contained in 9 basins using piscicides. This alternative would have less short-term adverse effects on invertebrates than alternative C, in which an additional 52 waterbodies and 15 mi (25 km) of streams contained in 17 basins would be treated using gill netting and electrofishing only;

- *slight long-term beneficial effects* on invertebrates in 25 treated waterbodies and 3.7 mi (6.0 km) of streams contained in seven basins, due to (1) invertebrate populations increasing in abundance, distribution and diversity in response to nonnative trout removal, and (2) the potential for extirpated MYLF populations to be reestablished in treated habitat. This alternative would have substantially less long-term beneficial effects on invertebrates than alternatives B and D, in which an additional 85 waterbodies and 31 mi (50 km) of streams contained in 21 basins would benefit from nonnative trout removal. This alternative would also have less long-term beneficial effects on invertebrates than alternative C, in which an additional 52 waterbodies and 15 mi (25 km) of streams contained in 17 basins would benefit from nonnative trout removal.

Cumulative effects on invertebrates would be slight, adverse and short term considering the numerous project activities underway across the parks and the region, and slight, long term and beneficial if the no action alternative results in the successful eradication of nonnative trout in the treatment areas.

Impacts from Elements Common to All Action Alternatives on Invertebrates

The following is the analyses of those elements common to all alternatives that could have an effect on the invertebrates.

<u>Crew Camps:</u> Crew camps would be located in upland areas away from water and thus away from core habitat for any aquatic invertebrates and zooplankton (see chapter 3) that may be present in the project area. Crews do collect water for drinking, cooking and washing. If aquatic invertebrates and zooplankton were present at a water collection area, this activity may sometimes cause individuals to exhibit a flight response, but the flight response would be no different than what would occur when visitors camp in these areas. These disturbances would be temporary in nature, and any individuals that took flight would typically resume their prior behaviors within a short amount of time. However, some individuals may be inadvertently captured during water collection. Although such individuals would not survive, it would result in little to no effect on their respective populations.

Terrestrial invertebrates such as ants, beetles and other insect groups would occasionally be present in or near crew camps (see chapter 3). Crew camp activity may sometimes cause individuals to exhibit a flight response, but the flight response would be no different than what would occur when visitors camp in these areas. These disturbances would be temporary in nature, and any individuals that took flight would typically resume their prior behaviors within a short amount of time. Some individuals may be inadvertently trampled by field crews. Although such individuals could be injured or perish, it would be expected to result in little effect on their respective populations.

Conclusion: The use of crew camps is therefore expected to result in *negligible effects* on invertebrates.

<u>Helicopter and Stock Support:</u> Effects on the invertebrates from the use of helicopters and stock to support the mobilization and demobilization of crew camps are expected to be similar to the effects from crew camps. Helicopter or stock would typically travel to and from crew camps in treatment areas twice

each summer, and would typically be present during daylight hours for 30 minutes (helicopter) to 2 hours (stock) during each support trip.

Noise from helicopters landing and taking off near crew camps would be temporary and away from water, and thus is expected to result in no effects on aquatic invertebrates and zooplankton because helicopters would be landing and taking off outside of their habitat area.

The presence of stock at crew camps would be temporary and mitigation would be utilized to keep stock away from water. Stock use is therefore expected to have a negligible effect on aquatic invertebrates and zooplankton because stock would be kept outside of their habitat area. The presence of stock animals could result in flight response by terrestrial invertebrates, but the flight response would be no different than what would occur when commercial, private or other administrative stock use may occur in these areas. These disturbances would be temporary in nature, and any individuals that took flight would typically resume their prior behaviors within a short amount of time. Some invertebrates may be inadvertently trampled by stock. Although such individuals could be injured or perish, it would be expected to result in little effect on their respective populations.

Conclusion: Helicopter and stock support would result in no to negligible effects on invertebrates.

<u>Fish Disposal:</u> From 2001 to 2013, the parks removed 50,201 nonnative fish from 23 lakes, and sections of associated streams. Fish were sunk to the bottom of fish-removal lakes and occasionally sunk in fish-removal streams. Although quantitative surveys to specifically document invertebrate mortality associated with nutrient or chemical changes from fish decomposition have not been done, field crews are onsite all season and conduct wildlife observations (NPS unpublished data). They have not noted any mortality events associated with fish decomposition, providing at least anecdotal evidence that there is not a noticeable impact on aquatic invertebrates.

Conversely, fish disposal may have had a beneficial effect on some invertebrates by releasing critical nutrients to low-productivity ecosystems characteristic of the high Sierra. Increased nutrients would support increased levels of algae, which in turn would support increased levels of benthic invertebrates. (Schindler et al. 2001).

Invertebrate individuals may sometimes exhibit a flight response near fish disposal activities, but the flight response would be no different than what would occur when visitors walk by these areas. These disturbances would be temporary in nature, and any individuals that took flight would typically resume their prior behaviors within a short amount of time.

Conclusion: Fish disposal would result in the following effects on the invertebrates:

- *no to short-term negligible adverse effects* due to fish disposal activities;
- *short-term beneficial effects* due to increase in nutrients released via fish decomposition during fish-removal years;
- long-term beneficial effects due to nutrient cycles returning to pre-trout levels of function (Schindler et al. 2001).

<u>Restoration of Mountain Yellow-Legged Frogs:</u> Active MYLF restoration involves human-assisted movement of a number of individuals from extant MYLF populations to other locations, in order to reestablish previously occupied habitat or augment dwindling populations. For invertebrates present at source and recipient sites, capture and release activities may sometimes cause individuals to exhibit a flight response, but the flight response would be no different than what would occur when visitors walk

by these areas. These disturbances would be temporary in nature, and any individuals that took flight would typically resume their prior behaviors within a short amount of time.

While these actions may temporarily disturb individuals of certain invertebrates, any new populations of MYLFs established or dwindling populations augmented would return or increase a natural component (MYLFs) of these systems that is known to provide benefits to ecosystem processes and native species including invertebrates (Knapp et al. 2001, Finlay and Vredenburg 2007). MYLFs are naturally adapted to these systems, such that frogs may affect invertebrate levels through predation; tadpoles cycle nutrient levels through algal grazing and waste excretion; and both tadpoles and frogs are prey to predatory invertebrates such as Dytiscid beetle larvae. Active ecosystem restoration of MYLFs is thus expected to result in beneficial effects on invertebrates.

Conclusion: Overall, active ecosystem restoration is expected to result in *no to short-term negligible adverse effects* and *short- and long-term beneficial effects* on the invertebrates.

<u>Monitoring:</u> Ecosystem monitoring activities that occur in selected waterbodies in the project area and that may affect the invertebrates include conducting shoreline visual encounter surveys to monitor the presence and abundance of MYLFs and other herpetofaunal species, and occasionally placing scientific measuring devices such as small data loggers to periodically measure and record water temperature.

For invertebrates present at monitoring sites, monitoring activities may sometimes cause individuals to exhibit a flight response, but the flight response would be no different than what would occur when visitors walk by these areas. These disturbances would be temporary in nature, and any individuals that took flight would typically resume their prior behaviors within a short amount of time. While these actions may temporarily disturb individuals of certain invertebrates, the data generated are important for informing managers on the status of native species and ecosystem attributes such as water temperature, and whether management actions are needed to conserve them.

Conclusion: Overall, monitoring is expected to result in *no to short-term negligible adverse effects* and *short- and long-term beneficial effects* on the invertebrates, due to the acquisition of current status data that would allow managers to quickly intervene if necessary to conserve them.

<u>Continuing Research:</u> Continuing research activities expected to occur in selected waterbodies in the project area and that may affect the invertebrates include refining methods to: (1) bathe MYLFs in an anti-fungal solution to reduce amphibian chytrid levels on frog skin, (2) add beneficial bacteria to MYLF skin to increase natural protection from amphibian chytrid fungus, and (3) reestablish MYLF populations where they recently died out or are dwindling toward extirpation due to amphibian chytrid fungus.

For invertebrates present at research sites, continuing research activities may sometimes cause individuals to exhibit a flight response, but the flight response would be no different than what would occur when visitors walk by these areas. These disturbances would be temporary in nature, and any individuals that took flight would typically resume their prior behaviors within a short amount of time. While these actions may temporarily disturb individuals of certain invertebrates, any populations of MYLFs that were assisted in surviving amphibian chytrid infection versus going extinct would have beneficial effects for invertebrates, as described in the “Restoration of Mountain Yellow-Legged Frogs” section.

Conclusion: Overall, continuing research is expected to result in *no to short-term negligible adverse effects* and *short- and long-term beneficial effects* on the invertebrates.

Cumulative Effects from Elements Common to All Action Alternatives - Invertebrates

The past, ongoing, and foreseeable future project activities within SEKI and in the Sierra Nevada region that could result in additive impacts on invertebrates include the past stocking of nonnative fish, the establishment and / or continued use of crew camps for general resource management, science, and maintenance activities, and trail maintenance work.

The past stocking and continued presence of native fish has altered the native food web and disrupted the type and distribution of species, and thus the natural function of the aquatic ecosystems across SEKI, and on adjacent lands. The impacts associated with the elements common to all action alternatives would result in slight or negligible adverse effects on invertebrates, but would not alter the type and distribution of species, and would not substantially contribute to the adverse effects that occurred as a result of this past action. Therefore, the cumulative effects from this project work would be insignificant when compared with these past actions.

The impacts from crew camps, science and resource activities, and trail work result primarily from disturbance associated with habitat disturbance that occurs around trail corridors. The level of impact, however, associated with these activities is small because crews are generally small, there is ample high quality and escape habitat available nearby, the impacts are localized and the duration of activities is temporary. Thus, these impacts would not substantially contribute to the overall cumulative effects.

The use of stock, when combined with similar activities under “Impacts from Elements Common to All Action Alternatives” would result in a slight potential for adverse effects on invertebrates around lakes, ponds, and streams, but these activities would not substantially contribute to the cumulative effects.

Fish disposal that would occur during this project may result in no to short-term negligible adverse effects and short- and long-term beneficial effects on invertebrates. However, there are no other similar actions occurring or expected to occur within the parks in the future that would have similar results as fish disposal. Therefore, there are no additive effects to invertebrates from this action and no cumulative effects.

Impacts of Alternative B: Prescription Treatment Preceding Restoration (Preferred Alternative) on Invertebrates

Under this alternative, nonnative fish would be removed from 85 waterbodies (31 lakes, 49 ponds, 5 associated marshes) an approximately 31 mi (50 km) of connected stream habitat contained in 21 basins (see Table 9, Table 10 and Table 11 and Figure 7 in chapter 2). Nonnative fish would be removed using physical methods (gill netting and electrofishing) from 52 waterbodies (27 lakes, 24 ponds, 1 marsh) and approximately 15 mi (25 km) of stream contained in 17 basins. Nonnative fish would be removed using piscicides (rotenone) from 33 waterbodies (4 lakes, 25 ponds, 4 marshes) and approximately 16 mi (25 km) of stream contained in 9 basins.

Effects on the invertebrates due to reestablishing extirpated MYLF populations in treated habitat would be the same as described under “Impacts from Elements Common to All Action Alternatives, Restoration of Mountain Yellow-legged Frogs” except that an additional 85 waterbodies and 31 mi (50 km) of streams would be treated and thus become available for active MYLF restoration.

Effects on the invertebrates due to crew activities would be the same as described under alternative A (no action), except that crew treatment activities would occur at an additional 85 waterbodies and 31 mi (50 km) of streams.

Effects on the invertebrates due to nonnative trout would be the same as described under alternative A (no action), except that nonnative fish would be eradicated from an additional 85 waterbodies and 31 mi (50 km) of streams, substantially reducing the overall impact on invertebrates.

Removal of nonnative trout from an additional 85 treatment waterbodies and 31 mi (50 km) of streams under alternative B would substantially expand aquatic invertebrate and zooplankton populations in treatment areas, resulting in substantial increases in the abundance, distribution and diversity of these assemblages. This amount of trout removal would also substantially expand MYLF populations in treatment areas and therefore substantially increase the number of MYLFs available to provide benefits to ecosystem processes and native species including invertebrates.

These 85 waterbodies comprise 15% of the parks' 550 high elevation waters that will contain nonnative trout after completion of the ongoing (previously approved) fish removal sites described in alternative A (no action). The continued presence of self-sustaining nonnative trout populations in the 465 waterbodies plus connecting streams (contained in 69 basins) left untreated would continue to adversely affect the invertebrates, primarily through predation but also through competition for limited food sources in these low-productivity environments.

Effects on the invertebrates due to gill-netting and electrofishing would be the same as described under alternative A (no action), except that gill-netting and electrofishing would be conducted in an additional 52 waterbodies and 15 mi (25 km) of streams.

Effects of Rotenone

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 Final EIS/EIR (FWS 2010)
- Proposed Use of Rotenone to Eradicate Northern Pike in Lake Davis, California Final 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. Potential effects of piscicide use on endemic invertebrates that may occur in the project area are also a matter of public concern as reflected in the project scoping comments.

This analysis evaluates potential effects of rotenone use on invertebrates using scientific findings from multiple relevant studies. In particular, it evaluates potential short- and long-term changes in abundance and species composition, natural disturbances that have effects similar to rotenone treatment, and time to recovery from both rotenone and natural disturbance. Effects are described based on rotenone toxicities to various aquatic invertebrates and zooplankton, as well as treatment design and habitat characteristics. A brief introductory overview of rotenone is also provided for context. See Appendices G and H for a comprehensive overview of piscicides including rotenone.

Rotenone Overview

Rotenone is toxic to many gill-breathing organisms when applied in water because it is readily absorbed across gill surfaces and quickly disrupts cellular aerobic respiration (Finlayson et al. 2000; see appendix G). 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 trout 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.

CFT Legumine™, which contains 5% active ingredient rotenone, is the formulation proposed for use under this alternative. EPA (2007A) limits CFT Legumine™ applications to a rate of no more than 1 ppm in streams and 4 ppm in lakes, concentrations that are strong enough to confidently eliminate all fish from these respective habitats (Ling 2003). At a CFT Legumine™ application rate of 1 ppm, the rotenone itself is initially present at 50 parts per billion (ppb; 1 ppm x 5% rotenone = 0.05 ppm = 50 ppb). For context, a ppb is equal to one part of a substance to a billion parts of water, or one billionth. An example would be one ppb of Interstate 80 between New York and San Francisco (~3000 mi / 4,800 km) is less than ¼ inch (CDFW 2007). In summary, trout are acutely sensitive to rotenone, quickly absorbing it through the gills and typically dying within hours at extremely low concentrations.

Short-Term Effects of Rotenone Treatment in Streams

Rotenone effects on various aquatic organisms have been reported from controlled toxicity tests that typically measure the LC50 value (median lethal concentration 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 23; 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 =~0.004 mg/L=3.5 ppb; Marking and Bills 1976).

Table 23. 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. Although rotenone exposure in lakes would continue past the application duration, it would diminish per rotenone’s expected half-life and is ultimately expected to be less than the 96 hr exposures used in these studies.

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 EPT 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 juvenile 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 juveniles were less susceptible to given concentrations of rotenone than smaller, younger juveniles 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. Because many invertebrates only reproduce once per year, 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, Trumbo et al. 2000a, 2000b, Whelan 2002, Darby et al. 2004).

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 (Table 24, 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.

Table 24. Toxicity values (in ppb) for rainbow trout fry and several invertebrates from 4-hour and 8-hour exposure to two rotenone formulations*

Species	4 hr LC50 Values		8 hr LC50 Values	
	CFT Legumine™	**Nusyn-Noxfish®**	**CFT Legumine™**	**Nusyn-Noxfish®**
Vertebrates				
Oncorhynchus mykiss	7.4	7.7	5.3	6.2
Invertebrates				
Caddisflies				
Arctopsyche grandis	ND	96**	34*	74*
Hydropsyche (tana and amblis)	274	ND	174	ND
Mayflies				
Baetis tricaudatus	ND	18	ND	23
Rhithrogena morrisoni	41	54*	40	13
Stoneflies				
Claassenia sabulosa	142	ND	60	ND
Oroperla barbara	197	70	102	57
Source: CDFW unpublished data ** - 24-hr observation ND – non-detectable				

**Values represent survival at 48 hours unless otherwise noted (FWS 2010).*

Recovery from Natural Disturbance in Streams

Streams actively change over time, with large changes often occurring in a short amount of time due to natural disturbances such as flood, drought and fire. Organisms that inhabit streams must therefore be able to adapt to dynamic environments. Piscicide treatments are similar to natural disturbances such as floods as they also cause large changes in a short amount of time. How aquatic invertebrates respond to natural disturbances therefore provides context for interpreting and evaluating potential long-term effects of proposed rotenone treatments.

Disturbance can be a discrete event that alters an ecosystem enough to: (1) disrupt its biological community (Yount and Niemi 1990), and/or (2) remove organisms and create conditions for recolonization (Vinson and Vinson 2007). Disturbances can have a cumulative effect on stream invertebrates over time and can also confound short- or long-term effects expected due to rotenone use.

Both natural and human-caused disturbances should therefore be considered in attempting to evaluate changes in aquatic invertebrate assemblages potentially due to rotenone application.

Available literature suggests the following generalizations on aquatic invertebrate recovery from natural disturbance and rotenone treatment. Invertebrate recovery times vary by disturbance type, distance to untreated populations as sources for recolonization, and characteristics of taxa in the assemblage such as generation times and dispersal capabilities (Vinson et al. 2010). Disturbance types vary in frequency, intensity, duration, geographic extent and timing (month or season of occurrence; Lake 2003). These attributes affect how stream invertebrates recover and how long it takes for assemblages to return to functional levels present before the disturbance occurred.

For example, floods are common, natural events that can substantially alter stream habitat and affect the composition and structure of invertebrate assemblages (Vinson et al. 2010). Stream invertebrates have low resistance to floods but typically high resilience (capacity to recover) following floods and other disturbances, with usually rapid recolonization rates (Lake 2000). However, recovery of invertebrate assemblages following floods varies widely, ranging from within weeks to several years (Niemi et al. 1990) depending on multiple factors.

Slower recovery occurs following floods with greater magnitude (Scrimgeour et al. 1988) or that occur in uncommon month or seasons (Feeley et al. 2012). In contrast, faster recovery occur after floods when assemblages have adaptations to frequently or unpredictably disturbed environments, such as rapid growth and development, lack of resting stages, small size, flexible life histories, and high adult mobility, longevity, and presence for most of year to lay eggs immediately after floods (Gray and Fisher 1981, Fisher et al. 1982, Townsend et al. 1997, Lake 2000).

Drought is another natural disturbance that can alter aquatic invertebrate assemblages. In one study, invertebrate recovery in two dewatered streams was affected by duration more than intensity (Fowler 2004). In another study, invertebrate populations in a stream dewatered by drought and treated with rotenone recovered immediately upon return of flows (Larimore et al. 1959), with winged reproductive adults showing up first, likely as colonizers from other streams. However, invertebrate larvae can also recolonize from the hyporheic zone, buffered habitat between stream bed substrates that provide refugia during droughts (Lake 2003).

Fire is another natural disturbance that can alter aquatic invertebrate assemblages. Studies of 20 streams in Yellowstone National Park over 10 years showed that although fire had large scale effects on riparian and stream habitat (Minshall et al. 2004), only minor direct effects to invertebrate assemblages were measured (Minshall 2003). Instead, indirect effects from increased runoff and channel alteration occurred. Community metrics such as species richness and diversity recovered strongly within one year after fire, while assemblage composition showed substantial changes 5 years after fire. Taxa easily dispersed through drift and having short generation times [Chironomidae (midges) and *Baetis* spp.], were found to adapt well to conditions following fire. Other taxa such as *Cinygmula* spp. (a mayfly) decreased in abundance soon after fire and showed little or no recovery 5 years later (Minshall et al.1997). Nevertheless, 10 years after fire, invertebrate density, biomass and richness recovered and did not differ from the reference streams (Minshall et al. 2003). The largest differences were in taxa dominance and similarity, with the relative abundances of Chironomidae and *Baetis* higher in burned versus reference streams.

Recovery (Long-Term Effects) from Rotenone Treatment in Streams

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. 2010B) for the proposed project, most fish removal projects in the past used higher dosages, including one with a maximum concentration of 470 ppb rotenone (Binns 1967). Currently, permitting and labeling requirements allow for a maximum concentration of 50 ppb rotenone (Zoecon 2015).

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, Trumbo et al. 2000, 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 legally allowed by the label. Using lower, legally allowed dosages would therefore limit effects of rotenone on macroinvertebrates.

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 (Trumbo et al. 2000a, 2000b, 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. Note that in SEKI's high elevation streams, return to pre-treatment community composition is not necessarily expected after nonnative trout (year-round predators of invertebrates) are removed. Where there have been major changes in predators, the expectation of return to pre-treatment conditions is misplaced; the approach of comparison to reference streams is more appropriate (e.g. RIVPACS; Hargett et al. 2007) so that variable results can be put into context.

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 mi 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 25 ppb rotenone for trout removal in streams (Zoecon 2015). 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 for normal tolerance species of 50 ppb rotenone and at least 6 times longer than currently recommended rotenone durations of less than 8 hours (Finlayson et al. 2010B). 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 two successive years. The treatments were applied at 150 ppb rotenone for 12 to 18 hours, which is 3 times the current limit for normal tolerance species 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 (currently 5 times the current limit for normal tolerance species of 50 ppb rotenone; Zoecon 2015) and then 100 ppb rotenone for 7 hours (2 times the current limit for normal tolerance species 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 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 (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. Since predators such as nonnative trout affect diversity and composition (e.g., by favoring more defended prey, removing dominants that suppress some taxa, or favoring more numerous but smaller-bodied insects that live in the protected hyporheic zone in streams or sediments in lakes), a more appropriate analysis would be to compare restored streams to nearby fishless streams of the same general elevation, hydrology and substrate type.

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. Nevertheless, high elevation streams are not likely to have nearly as much diversity as major river systems at lower elevations.

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 13), 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 lake 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. 2010B). 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 aerial dispersal of winged life stages.

- 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.

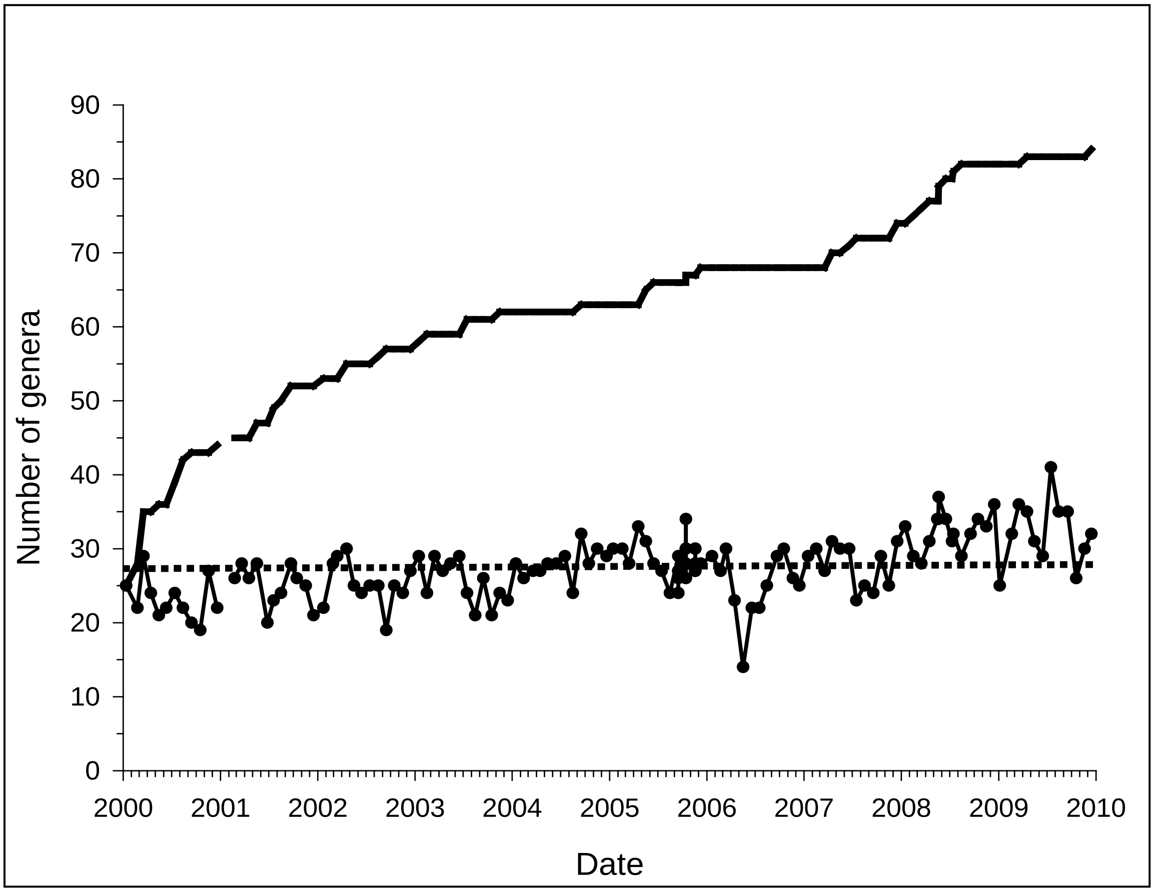

Figure 13. Monthly collections and genera accumulation curves for benthic aquatic invertebrates collected from the Logan River, Cache County, Utah

Figure 13 shows the monthly collections and genera accumulation curves for benthic aquatic invertebrates collected from the Logan River, Cache County, Utah between January 2000 and December 2009. Solid lines are individual monthly values (bottom) and cumulative collection (top) of unique genera. The dotted line is the long-term mean and median of 27.5 genera per sample. Five samples were collected per month in September–December 2005, three samples were collected in May 2008, and two in July 2008. No sample was collected in January 2001. Figure provided courtesy of Vinson et al. (2010).

Short-Term Effects of Rotenone Treatment in Lakes

The effects of rotenone on lake invertebrates have been reported in several studies dating to the 1940s (Vinson et al. 2010). Study results were highly variable, and the authors concluded that much of the variation was likely related to differences in rotenone dosage (concentration x duration). Variation in study results also appeared related to amounts of pre- and post-treatment sampling, which ranged from one sample to 1+ year of pre-treatment sampling, and from one sample to 4 years of post-treatment sampling. Studies that conducted less sampling generally reported fewer effects.

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, Table 23 (above) shows 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, most 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, Koksvik and Aagaard 1984, Melaas et al. 2001). The greatest effects appear to have been on Chironomidae (midges), which can be the most dominant taxa in invertebrate assemblages.

Recovery (Long-Term Effects) of Rotenone Treatment in Lakes

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 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).

Rotenone Conclusion

Piscicide treatments are therefore expected to have short-term major adverse effects, long-term moderate adverse effects, and long-term substantial beneficial effects on the invertebrates.

Cumulative Effects – Alternative B - Invertebrates

The most substantial past action that has adversely affected invertebrates throughout the Sierra Nevada is nonnative fish stocking. Additional actions that could affect vertebrates when considering the additive impacts from alternative A include past, ongoing, and future aquatic ecosystem restoration projects outside the project area but within the area of cumulative effect (SEKI, YOSE, and Inyo, Sequoia, and Sierra National Forests), and trail maintenance projects outside the project area but within the area considered for the cumulative effects analysis.

Under alternative B, self-sustaining nonnative trout populations would remain in 465 additional lakes, ponds, and marshes known to contain fish, plus hundreds of miles of connected stream habitat. The eradication of nonnative fish in an additional 85 waterbodies and 31 mi (50 km) of streams and active restoration of MYLFs under alternative B would substantially benefit invertebrates. Because the scope and scale of this alternative are large, it would result in substantial long-term beneficial effects on invertebrates within SEKI. If the projects outside the parks described above are able to restore populations of frogs and invertebrates, then they would also benefit invertebrates. However, these projects are limited in scope and scale compared to the thousands of high elevation waterbodies that exist in the area of cumulative effect. The past stocking and continued presence of native fish has altered the native food web and disrupted the type and distribution of species, and thus the natural function of the aquatic ecosystems across SEKI, and on adjacent lands. Outside the parks in the Sierra Nevada region, nonnative trout occupy about 2,000 lakes greater than 2.5 ac (1 ha) in surface area (Bahls 1992, Knapp 1996), an unknown number of ponds less than 2.5 ac (1 ha; estimated in the thousands), plus connecting streams. While this alternative would result in fewer waterbodies in the parks with nonnative fish species, and it would benefit invertebrate species and native ecosystems within the parks, it would not substantially contribute to the restoration of native ecosystems and native invertebrate populations across the Sierra Nevada. The cumulative effects, if recovery efforts are successful, would be important and beneficial within the parks, and slight and beneficial region-wide.

For projects using gill netting and electrofishing outside the parks in the area of cumulative effect, short-term adverse effects on invertebrates are the same as described under the no action alternative. In summary, these projects would not appreciably add to the short-term adverse effects to invertebrates when combined with the effects from alternative B.

There has been limited past use of piscides in the parks. In 1979, antimycin A was used to successfully eradicate nonnative brook trout from Hidden Lake and connected stream reaches (Christenson 1984) to contribute to the recovery of federally threatened Little Kern golden trout. However, the impacts from this action ended long ago, and thus there are no additive effects on the invertebrates from this action. There are no other past, ongoing, or future planned project activities within the parks that used or propose the use of piscicides. Herbicide use occasionally occurs within the parks as part of a weed management program, but no projects are planned in or near project areas or near lakes, rivers, or streams in the foreseeable future that would utilize herbicides.

Outside the parks piscicides were used several times between 1976 and 1994 to eradicate certain populations of hybrid and competitor fish for California golden trout restoration in the South Fork Kern River (Pister 2008) and Little Kern golden trout restoration in the Little Kern River (Christenson 1984). However, the impacts from these actions ended long ago, and thus there are no additive effects on the invertebrates from these actions. There are no other past, ongoing, or future planned project activities outside the parks in the area of cumulative effect that used or propose the use of piscicides.

Conclusion: Overall, alternative B is expected to result in the following effects on the invertebrates:

- *short-term major adverse effects* are possible for some invertebrate species from piscicide treatment in an additional 33 waterbodies and 16 mi (25 km) of streams contained in 9 basins, due to disturbance, injury or mortality to individuals and reduction in abundance and diversity of populations. This alternative would also have short-term negligible to minor adverse effects on invertebrates from gill netting and electrofishing in an additional 52 waterbodies and 15 mi (25 km) of streams contained in 17 basins, due to the potential for disturbance, injury or mortality to individuals. This alternative would have less short-term adverse effects on invertebrates than alternative D, in which an additional 85 waterbodies and 31 mi (50 km) of streams contained in 21 basins would be treated using piscicides only. This alternative would have more short-term adverse effects on invertebrates than alternative C, in which an additional 52 waterbodies and 15 mi (25 km) of streams contained in 17 basins would be treated using gill netting and electrofishing only. This alternative would have substantially more short-term adverse effects on invertebrates than alternative A, in which no additional waterbodies would be treated;

- long-term moderate adverse effects are possible for some invertebrate species from piscicide treatment in an additional 33 waterbodies and 16 mi (25 km) of streams contained in 9 basins, due to the potential for prolonged reduction in abundance and diversity of populations. This alternative would have less long-term adverse effects on invertebrates than alternative D, in which an additional 85 waterbodies and 31 mi (50 km) of streams contained in 21 basins would be treated using piscicides only. This alternative would have more long-term adverse effects on invertebrates than alternative C, in which an additional 52 waterbodies and 15 mi (25 km) of streams contained in 17 basins would be treated using gill netting and electrofishing only. This alternative would have substantially more long-term adverse effects on invertebrates than alternative A, in which no additional waterbodies would be treated;

- substantial long-term beneficial effects on invertebrates in an additional 85 waterbodies and 31 mi (50 km) of streams contained in 21 basins, due to: (1) invertebrate populations increasing in abundance, distribution and diversity in response to nonnative trout removal, and (2) the potential for extirpated MYLF populations to be reestablished in treated habitat. This alternative would have the same long-term beneficial effects on invertebrates as alternative D. This alternative would have more long-term beneficial effects on invertebrates than alternative C, in which an additional 52 waterbodies and 15 mi (25 km) of streams contained in 17 basins would benefit from nonnative trout removal. This alternative would have substantially more long-term beneficial effects on invertebrates than alternative A, in which no additional waterbodies would benefit from nonnative trout removal.

Cumulative effects on invertebrates would be slight, adverse and short term considering the numerous project activities underway across the parks and the region, and slight to substantial, long term and beneficial if alternative B results in the successful eradication of nonnative trout in the treatment areas.

Impacts of Alternative C: Physical Treatment Preceding Restoration on Invertebrates

Under this alternative, nonnative fish would be removed from 52 waterbodies (27 lakes, 24 ponds, 1 marsh) and approximately 15 mi (25 km) of connected stream habitat contained in 17 basins (see Table 9 and Table 14 and Figure 9 in chapter 2). Nonnative fish would be removed using physical methods only (gill netting and electrofishing). Blasting rock to create vertical fish barriers in these physical treatment areas would be conducted (if determined necessary) at up to five natural cascades.

Effects on the invertebrates due to reestablishing extirpated MYLF populations in treated habitat would be the same as described under “Impacts from Elements Common to All Action Alternatives, Restoration of Mountain Yellow-legged Frogs” except that an additional 52 waterbodies and 15 mi (25 km) of streams would be treated and thus become available for active MYLF restoration.

Effects on the invertebrates due to crew activities would be the same as described under alternative A (no action), except that crew treatment activities would occur at an additional 52 waterbodies and 15 mi (25 km) of streams.

Effects on the invertebrates due to nonnative trout would be the same as described under alternative A (no action), except that nonnative fish would be eradicated from an additional 52 waterbodies and 15 mi (25 km) of streams, reducing the overall impact on invertebrates.

Removal of nonnative trout from an additional 52 waterbodies and 15 mi (25 km) of streams under alternative C would expand aquatic invertebrate and zooplankton populations in treatment areas, resulting in increases in the abundance, distribution and diversity of these assemblages. This amount of trout removal would also expand MYLF populations in treatment areas and therefore increase the number of MYLFs available to provide benefits to ecosystem processes and native species including invertebrates.

These 52 waterbodies comprise 9% of the parks’ 550 high elevation waters that will contain nonnative trout after completion of the ongoing (previously approved) fish removal sites described in alternative A (no action).

Effects on the invertebrates due to gill-netting and electrofishing would be the same as described under alternative A (no action), except that gill-netting and electrofishing would be conducted in an additional 52 waterbodies and 15 mi (25 km) of streams.

Effects on the invertebrates due to blasting rock, if determined necessary to create vertical fish barriers, include the following. First, it is estimated that blasting would become necessary at no more than five locations (natural cascades) over the duration of the project. Second, blasting would occur in late summer when stream are at their lowest flows of the season, thereby limiting the number of aquatic invertebrates that could be present. Many invertebrates present as crews begin blasting work would be expected to exhibit a flight response. These disturbances would be temporary in nature, and any individuals that took flight would typically resume their prior behaviors in a distant location within a short amount of time. However, there is potential for some invertebrates to seek cover within the immediate work area rather than exhibiting a flight response out of the work area. If this occurred, there would be potential for those individuals to be injured or perish during a blast, either from the force of the blast or by rock projectiles. Any injury or mortality to individual invertebrates from blasting would be expected to result in little effect on their respective populations of those species. In the long-term, blasting rock to create vertical fish barriers would allow certain treatment areas to be fully eradicated of trout, which would result in long-term beneficial effects to the invertebrates due to expected increases in (1) the abundance and distribution of many taxa and (2) the diversity of invertebrate assemblages.

Cumulative Effects – Alternative C - Invertebrates

The cumulative effects on invertebrates under alternative C are similar to those described under alternatives A and B. Under alternative C, 33 fewer waterbodies and 16 fewer miles (25 km) of streams would be eradicated of nonnative fish, no piscicides would be used, and blasting rock would be used (if determined necessary) at up to five cascades.

As described under alternative B and C, the continued presence of self-sustaining nonnative trout populations in the 498 waterbodies plus connecting streams (contained in 80 basins) left untreated would continue to adversely affect the invertebrates, primarily through predation but also through competition for limited food sources in these low-productivity environments. While this alternative would result in fewer waterbodies in the parks with nonnative fish species, and it would benefit invertebrate species and native ecosystems within the parks, it would not substantially contribute to the restoration of native ecosystems and native invertebrate populations across the Sierra Nevada. The cumulative effects, if recovery efforts are successful, would be important and beneficial within the parks, and slight and beneficial region-wide.

Projects using gill netting and electrofishing outside the parks would result in the same cumulative effects on invertebrates as described under the no action alternative. In summary, these projects would not appreciably add to the short-term adverse effects to invertebrates when combined with the effects from alternative C. There would be long-term beneficial effects on invertebrates when combined with the other ecosystem restoration projects outside the parks, however this alternative would not contribute substantially to the overall beneficial effects on vertebrates because it is limited in scope and scale, though it would be more beneficial than alternative A. While this alternative would result in fewer waterbodies in the parks with nonnative fish species, and it would benefit invertebrate species and native ecosystems within the parks, it would not substantially contribute to the restoration of native ecosystems and native vertebrate populations across the Sierra Nevada. The cumulative effects, if recovery efforts are successful, would be important and beneficial within the parks, and slight and beneficial region-wide.

Trail maintenance projects routinely use blasting in terrestrial areas but do not blast in streams in rivers but could blast proximate to these areas. There could be slight and temporary effects on invertebrates from disturbance, injury, or mortality to individuals. Effects on invertebrates from trail blasting projects outside the project area would be localized and would not appreciably add to the short-term adverse effects on invertebrates when combined with the effects from alternative C. There would be no discernable or slight adverse cumulative effects on invertebrates from blasting actions.

Conclusion: Overall, this alternative is expected to result in the following effects on the invertebrates:

- *short-term negligible to minor adverse effects* on invertebrates from gill netting and electrofishing in an additional 52 waterbodies and 15 mi (25 km) of streams contained in 17 basins, and if blasting rock is needed to create vertical fish barriers in up to 5 locations, due to the potential for disturbance, injury or mortality to individuals. This alternative would have substantially less short-term adverse effects on invertebrates than alternative D, in which 85 waterbodies and 31 mi (50 km) of streams contained in 21 basins would be treated using piscicides only. This alternative would have less short-term adverse effects on invertebrates than alternative B, in which an additional 52 waterbodies and 15 mi (25 km) of streams contained in 17 basins would be treated using gill netting and electrofishing, and 33 waterbodies and 16 mi (25 km) of streams contained in 9 basins would be treated using piscicides. This alternative would have more short-term adverse effects on invertebrates than alternative A (no action), in which no additional waterbodies would be treated;

- *long-term beneficial effects* on invertebrates in an additional 52 waterbodies and 15 mi (25 km) of streams contained in 17 basins, due to: (1) invertebrate populations increasing in abundance, distribution, and diversity in response to nonnative trout removal, and (2) the potential for extirpated MYLF populations to be reestablished in treated habitat. This alternative would have less long-term beneficial effects on invertebrates than alternatives B and D, in which an additional 85 waterbodies and 31 mi (50 km) of streams contained in 21 basins would benefit from nonnative trout removal. This alternative would have more long-term beneficial effects on invertebrates than alternative A, in which no additional waterbodies would benefit from nonnative trout removal.

Cumulative effects on invertebrates would be slight, adverse and short term considering the numerous project activities underway across the parks and the region, and slight to substantial, long term and beneficial within SEKI if alternative C results in the successful eradication of nonnative trout in the treatment areas, and would result in slight and beneficial cumulative effects on native invertebrates across the region if other areas are successfully restored.

Impacts of Alternative D: Piscicide Treatment Preceding Restoration on Invertebrates

Under this alternative, nonnative fish would be removed from 85 waterbodies (31 lakes, 49 ponds, 5 associated marshes) and approximately 31 mi (50 km) of connected stream habitat contained in 21 basins (see Table 9 and Table 15, and Figure 10 in chapter 2). Nonnative fish would be removed using piscicides only (rotenone). Blasting rock to create vertical fish barriers would not be conducted because using piscicides in all fish eradication locations would render it unnecessary. Self-sustaining nonnative trout populations would remain in 465 additional lakes, ponds, and marshes known to contain fish, plus hundreds of miles of connected stream habitat.

Effects on the invertebrates due to reestablishing extirpated MYLF populations in treated habitat would be the same as described under “Impacts from Elements Common to All Action Alternatives, Restoration of Mountain Yellow-legged Frogs” except that an additional 85 waterbodies and 31 mi (50 km) of streams would be treated and thus become available for active MYLF restoration.

Effects on the invertebrates due to crew activities would be the same as described under alternative A (no action), except that crew treatment activities would occur at an additional 85 waterbodies and 31 mi (50 km) of streams.

Effects on the invertebrates due to nonnative trout would be the same as described under alternative A (no action), except that nonnative fish would be eradicated from an additional 85 waterbodies and 31 mi (50 km) of streams, reducing the overall impact on invertebrates.

Removal of nonnative trout from an additional 85 waterbodies and 31 mi (50 km) of streams under alternative D would substantially expand aquatic invertebrate and zooplankton populations in treatment areas, resulting in substantial increases in the abundance, distribution and diversity of these assemblages. This amount of trout removal would also substantially expand MYLF populations in treatment areas and therefore substantially increase the number of MYLFs available to provide benefits to ecosystem processes and native species including invertebrates.

These 85 waterbodies comprise 15% of the parks' 550 high elevation waters that will contain nonnative trout after completion of the ongoing (previously approved) fish removal sites described in alternative A (No action).

Effects on vertebrates due to piscicide use would be the same as described under alternative B, except that piscicides would be used to eradicate nonnative trout in an additional 52 waterbodies and 15 mi (25 km) of streams compared to alternative B, increasing adverse effects on invertebrates.

Cumulative Effects – Alternative D - Invertebrates

The cumulative effects on invertebrates under alternative D are similar to those described under alternative B, except that 52 more waterbodies and 15 more mi (25 km) of streams would be eradicated of nonnative fish using piscicides, and no gill netting, electrofishing or blasting would be used. The continued presence of self-sustaining nonnative trout populations in the 465 waterbodies plus connecting streams (contained in 69 basins) left untreated would continue to adversely affect the invertebrates, primarily through predation but also through competition for limited food sources in these low-productivity environments. While this alternative would result in fewer waterbodies in the parks with nonnative fish species, and it would benefit invertebrate species and native ecosystems within the parks, it would not substantially contribute to the restoration of native ecosystems and native invertebrate populations across the Sierra Nevada. The cumulative effects, if recovery efforts are successful, would be important and beneficial within the parks, and slight and beneficial region-wide.

Conclusion: Overall, this alternative is expected to result in the following effects on the invertebrates:

- *short-term major adverse effects* are possible for some invertebrate species from piscicide use in an additional 85 waterbodies and 31 mi (50 km) of streams contained in 21 basins, due to disturbance, injury or mortality to individuals and reduction in abundance and diversity of populations. This alternative would have more short-term adverse effects on invertebrates than alternative B, in which an additional 52 waterbodies and 15 mi (25 km) of streams contained in 17 basins would be treated using gill netting and electrofishing, and an additional 33 waterbodies and 16 mi (25 km) of streams contained in 9 basins would be treated using piscicides. This alternative would have more short-term adverse effects on invertebrates than alternative C, in which an additional 52 waterbodies and 15 mi (25 km) of streams contained in 17 basins would be treated using gill netting and electrofishing only. This alternative would have substantially more short-term adverse effects on invertebrates than alternative A, in which no additional waterbodies would be treated;
- *long-term moderate adverse effects* are possible for some invertebrate species from piscicide use in an additional 85 water and 31 mi (50 km) of streams contained in 21 basins, due to the potential for prolonged reduction in abundance and diversity of populations. This alternative would have more long-term adverse effects on invertebrates than alternative B, in which an additional 33 waterbodies and 16 mi (25 km) of streams contained in 9 basins would be treated using piscicides. This alternative would have substantially more long-term adverse effects on invertebrates than alternatives A and C, in which no waterbodies would be treated with piscicides;
- *substantial long-term beneficial effects* on invertebrates in an additional 85 waterbodies and 31 mi (50 km) of streams contained in 21 basins, due to: (1) invertebrate populations increasing in abundance, distribution and diversity in response to nonnative trout removal, and (2) the potential for extirpated MYLF populations to be reestablished in treated habitat. This alternative would have the same long-term beneficial effects on invertebrates as alternative B. This alternative would have more long-term beneficial effects on invertebrates than alternative C, in which an additional 52 waterbodies and 15 mi (25 km) of streams contained in 17 basins would benefit

from nonnative trout removal. This alternative would have substantially more long-term beneficial effects on invertebrates than alternative A, in which no additional waterbodies would benefit from nonnative trout removal.

Cumulative effects on invertebrates would be slight, adverse and short term considering the numerous project activities underway across the parks and the region, and slight to substantial, long term and beneficial if alternative D results in the successful eradication of nonnative trout in the treatment areas.

WILD AND SCENIC RIVERS

Methodology for Analyzing Impacts

The impact analysis evaluates how each alternative would affect outstandingly remarkable values for designated wild and scenic rivers within or near the proposed project areas. While none of the alternatives have actions that would occur within the designated segment of a designated or eligible wild and scenic river, actions are proposed either on tributaries or in the watersheds that feed into designated or eligible wild and scenic rivers. Because one alternative proposes to alter a tributary of a wild and scenic river by blasting barriers (if needed), a section 7(a) determination has been prepared to evaluate the potential of the actions described in the Restoration Plan/FEIS to either invade or diminish the scenic, recreational, fish, or wildlife values of the wild and scenic river (appendix K).

Wild and scenic rivers (either designated or eligible) that could be affected by one or more of the alternatives include the Middle Fork and South Fork of the Kings River, and the North Fork of the Kern River (Figure 14). Proposed fish eradication basins that contain portions of these rivers or are watersheds feeding these rivers are Dusy, Rambaud, Barrett, Amphitheater, Horseshoe, Slide and Swamp for the Middle Fork of the Kings River; Sixty Lake, Brewer, Vidette and Upper Bubbs for the South Fork of the Kings River; and Upper Kern, Milestone, East Wright, Laurel, and Crytes for the North Fork of the Kern River. None of the proposed restoration sites are within the designated segments of these rivers. Therefore, none of the restoration activities would occur within the designated segments of any wild and scenic rivers. All of the sites proposed for piscicide use, except one, are far from designated wild and scenic rivers or river segments. The site in Upper Kern is proposed for piscicide treatment and is near the headwaters of the North Fork of the Kern River, which is designated as “Wild” under the Wild and Scenic Rivers Act. The furthest downstream points in the two streams proposed for piscicide treatment are approximately 200 meters and 250 meters upstream of the wild and scenic river boundary. While no work would occur directly within designated sections of these rivers, proposed fish eradication basins would be located within the watersheds feeding these rivers.

None of the alternatives would affect the free-flowing character of any designated wild and scenic river, but alternative C could affect the free-flowing character of a tributary to a designated wild and scenic river. Outstandingly remarkable values which could be affected by project activities include scenic, recreational, fish, and wildlife. Impacts are evaluated in general terms of whether they would be beneficial or adverse to these outstandingly remarkable values (ORV; Table 25) and a conclusion is drawn as to whether ORV would be protected and enhanced as a result of the project. This section focuses

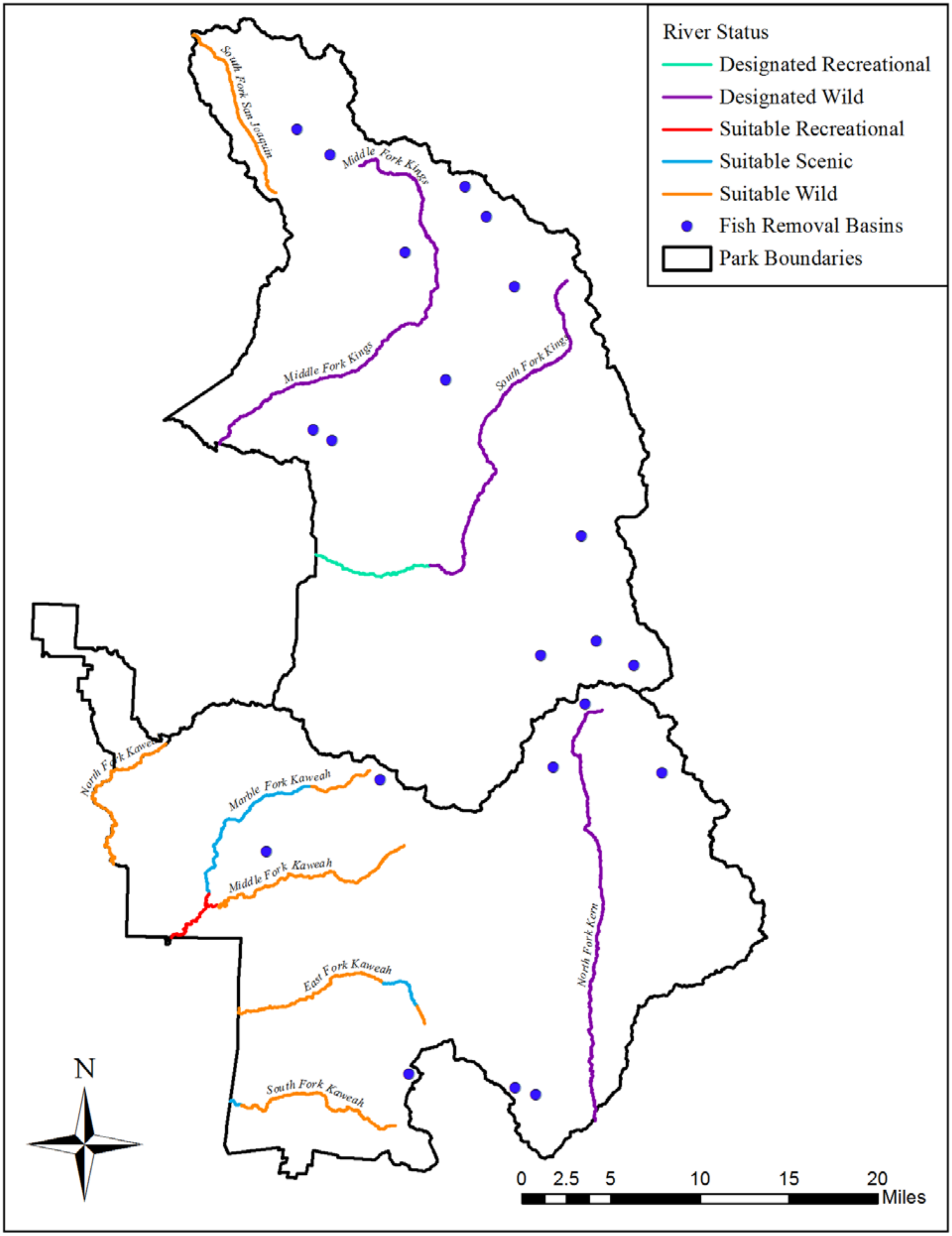

Figure 14. Locations of proposed fish eradication basins in relation to Designated and Suitable Wild and Scenic Rivers in SEKI

on specific attributes of designated ORV that are not discussed elsewhere in this chapter. Impacts to water quality, recreational use in general, fish, and wildlife are fully evaluated in previous or following sections of this chapter. Effects of piscicide use on water quality are discussed in the water quality impact topic in chapter 4.

The duration of the impact considers whether the impact would be temporary and/or associated with transitional types of activities or if the impact would occur over a longer period.

Table 25. Wild and Scenic Rivers Impact and Intensity Descriptions

Impact Intensity	Intensity Description
Negligible	Impacts would not be detectable to most visitors and would have no discernible effect on a river's outstandingly remarkable values.
Minor	Impacts would be slightly detectable to some visitors but are not expected to have an overall effect on a river's outstandingly remarkable values.
Moderate	Impacts would be clearly detectable by many visitors and could have an appreciable effect on a river's outstandingly remarkable values.
Major	Impacts would have a substantial and noticeable effect to most visitors or the river's outstandingly remarkable values.

Short-term—Impacts occur during project work.

Long-term—Impacts are ongoing after project work is completed.

Impacts of Alternative A: No action on Wild and Scenie Rivers

Impacts on Outstandingly Remarkable Values: The impacts associated with the current program are the physical removal of nonnative fish prior to restoration. There would be no work within the designated segments of wild and scenic rivers and therefore no direct beneficial or adverse effects resulting from this alternative on the outstandingly remarkable river values. There would be long-term beneficial effects on native fish and wildlife populations (see previous sections: Impacts to Special-status Species, Wildlife, and Visitor Experience and Recreational Opportunities) and this would result in beneficial effects within the tributary areas of wild and scenic rivers. These effects, such as increased chances of wildlife viewing, could cascade down the basins, indirectly enhancing certain attributes of the recreation, fish, and wildlife ORV inside designated sections of the wild and scenic rivers.

Cumulative Effects – Alternative A – Wild and Scenic Rivers

The 2007 GMP established a vision for the management of wild and scenic rivers within SEKI, and identified river protection measures that are employed for projects within the river boundaries (extending 0.25 mile on each side of the designated river sections), tributaries and the overall watershed. This project meets the goals established by the GMP and adheres to the river protection measures. The project areas are remote and the outstandingly remarkable values are protected in parks' wilderness areas. No past, ongoing, and future proposed actions are degrading the outstandingly remarkable values of designated wild and scenic rivers within the parks, thus there are no cumulative effects.

Conclusion: There would be indirect *long-term beneficial effects* on recreation, fish, and wildlife ORVs in tributaries upstream of designated wild and scenic rivers, but no direct adverse or beneficial effects to designated wild and scenic rivers and no cumulative effects.

Impacts from Elements Common to All Action Alternatives on Wild and Scenic Rivers

Impacts on Outstandingly Remarkable Values (Scenic, Recreational, Fish and Wildlife): Crew camps, helicopter use, and restoration of mountain yellow-legged frogs, monitoring, research, and fish disposal would have no direct effects on designated ORV because none of these activities would occur within designated river segments. Stock use would pass through river corridors. These trips would be minimal but sometimes would involve overnight stays. In upper basin areas upstream from wild and scenic rivers, there would be no effects on scenic values because crews working and camping in project areas would not be visible from a wild and scenic river or its banks. Recreational, fish, and wildlife values in areas upstream of wild and scenic rivers would be changed as ecosystems are restored, primarily due to an increase in opportunities to view native wildlife; and these changes would have the potential to spread into the designated wild and scenic river segments in the future. This would result in beneficial effects to the recreation, fish, and wildlife ORV.

Cumulative Effects from Elements Common to All Action Alternatives on Wild and Scenic Rivers

In the long-term, outstandingly remarkable values would continue to be protected in the parks' wild and scenic rivers. The project areas are remote and the outstandingly remarkable values are protected in parks' wilderness areas. No past, ongoing, and future proposed actions are degrading the outstandingly remarkable values of designated wild and scenic rivers within the parks, thus there are no cumulative effects.

Impacts of Alternative B: Prescription Treatment Preceding Restoration (Preferred Alternative) on Wild and Scenic Rivers

Impacts on Outstandingly Remarkable Values: The impacts associated with physical treatment would be the same as alternative A only expanded to include additional sites in Dusy, Rambaud, Barrett, Amphitheater, Horseshoe, Slide and Swamp, which are upstream from the Middle Fork of the Kings River; Sixty Lake, Brewer, Vidette and Upper Bubbs, which are upstream from the South Fork of the Kings River; and Upper Kern, Milestone, East Wright, Laurel and Crytes, which are upstream from the North Fork of the Kern River. All of these treatment sites are outside the designated portions of these wild and scenic rivers. In addition, this alternative involves the proposed use of piscicides in selected treatment sites. All of the sites proposed for piscicide use, except one, are far from designated wild and scenic rivers or river segments. The site in Upper Kern basin is proposed for piscicide treatment and is near the headwaters of the North Fork of the Kern River, which is designated as "Wild" under the Wild and Scenic Rivers Act. The furthest downstream points in the two streams proposed for piscicide treatment are approximately 650 ft and 820 ft (200 m and 250 m) upstream of the wild and scenic river boundary.

The treatment with piscicides could result in short-term adverse effects to the recreation, fish, and wildlife ORV upstream from designated wild and scenic rivers. However, because the furthest downstream treatment site is 650 ft (200 m) upstream of the wild and scenic river boundary, there would be no direct effect to designated wild and scenic rivers. Yearly treatments would involve less than 3 mi (4.8 km) of stream and generally no more than three lakes. Some years there may be no piscicide treatments in this area. Piscicides would cause mortality to all gill breathing organisms in the treatment site, which would have major adverse effects to the fish and gill-breathing wildlife upstream of the designated wild and scenic river segment. However, this effect would be short-term as native wildlife populations are expected to recover, based on similar work at other areas (Vinson et al. 2010).

There would be long-term beneficial effects on native fish and wildlife populations (see previous sections: Impacts to Special Status Species, Wildlife, and Visitor Experience and Recreational Opportunities) and this would result in beneficial effects within the tributary areas of wild and scenic rivers. These effects, such as increased chances of wildlife viewing, could cascade down the basins, indirectly enhancing certain attributes of the recreation, fish, and wildlife ORV inside designated sections of the wild and scenic rivers. While there would be beneficial for the recreation, fish, and wildlife ORV in the long term to tributaries of designated wild and scenic rivers, there would be no direct effects.

Cumulative Effects – Alternative B – Wild and Scenic Rivers

In the long-term, outstandingly remarkable values would continue to be protected in the parks' wild and scenic rivers. The project areas are remote and the outstandingly remarkable values are protected in parks' wilderness areas. No past, ongoing, and future proposed actions are degrading the outstandingly remarkable values of designated wild and scenic rivers within the parks, thus there are no cumulative effects.

Conclusion: There would be indirect *long-term beneficial effects* on recreation, fish, and wildlife ORVs in tributaries upstream of designated wild and scenic rivers, but no direct adverse or beneficial effects to designated wild and scenic rivers and no cumulative effects.

Impacts of Alternative C: Physical Treatment Preceding Restoration on Wild and Scenic Rivers

<u>Impacts on Outstandingly Remarkable Values:</u> The impacts associated with physical treatment would be the same as alternative B. In upper basin areas upstream of designated wild and scenic river segments, there would be decreased angling opportunities in the short and long term, and increased recreational opportunities associated with viewing native wildlife in the long term. Alternative C could adversely affect the free-flowing character of a tributary to a designated wild and scenic river if blasting occurs, permanently altering the river bed in order to create a vertical fish barrier. Within the designated wild and scenic river segments, there would be no effects on the recreation, fish, and wildlife ORVs.

Cumulative Effects – Alternative C – Wild and Scenic Rivers

The cumulative effects would be the same as alternative B.

Conclusion: There would be indirect *long-term beneficial effects* on recreation, fish, and wildlife ORVs in tributaries upstream of designated wild and scenic rivers, an adverse effect to the free-flowing nature of a tributary to a wild and scenic river, but no direct adverse or beneficial effects to designated wild and scenic rivers and no cumulative effects.

Impacts of Alternative D: Piscicide Treatment Preceding Restoration on Wild and Scenic Rivers

<u>Impacts on Outstandingly Remarkable Values:</u> This alternative would be similar to alternative B, only more areas would be treated with piscicides and work would occur over a shorter period of time. All of the sites except one are far from designated wild and scenic rivers or river segments. One site (Upper Kern Basin) proposed for piscicide treatment is near the headwaters of the North Fork of the Kern River. The furthest downstream points in the two streams proposed for piscicide treatment are approximately 650 ft and 820 ft (200 m and 250 m) upstream of the wild and scenic river boundary. The North Fork of the Kern River is designated as "Wild" under the Wild and Scenic Rivers Act. As explained in alternative B, there would be long-term adverse effects on recreational opportunities related to decreased recreation (fishing) in upper basin areas upstream of the designated wild and scenic rivers, and long-term beneficial effects on the recreation, fish, and wildlife ORV within the designated wild and scenic river segments.

Cumulative Effects – Alternative D – Wild and Scenic Rivers

The cumulative effects to outstandingly remarkable values would be the same as alternative B.

Conclusion: There would be indirect *long-term beneficial effects* on recreation, fish, and wildlife ORVs in tributaries upstream of designated wild and scenic rivers, but no direct adverse or beneficial effects to designated wild and scenic rivers and no cumulative effects.

WATER QUALITY

Methodology for Analyzing Impacts

NPS *Management Policies 2006* state that the NPS will "take all necessary actions to maintain or restore the quality of surface waterbodies and within the parks consistent with the Clean Water Act and all other applicable federal, state, and local laws and regulations" (sec. 4.6.3).

A water quality standard defines the water quality goals of a waterbody by designating uses to be made of the water, by setting minimum criteria to protect the uses, and by preventing degradation of water quality through antidegradation provisions. The antidegradation policy is only one portion of a water quality standard. Part of this policy (40 CFR 131.12(a)(2) and California Resolution No. 68-16) strives to maintain water quality at existing levels if it is already better than the minimum criteria. Antidegradation should not be interpreted to mean that "no degradation" can or will occur, as even in the most pristine waters, degradation may be allowed for certain pollutants as long as it is temporary.

The impact analysis evaluates how project work would affect surface water quality in up to 55 basins, depending on the alternative (Table 26). Surface water quality could be affected by one or more of the alternatives. Potential impacts from the use of piscicides are based on professional judgment and experience with similar actions, available literature, and similar studies and project activities. Each alternative was examined to determine its effect on surface water (lakes, ponds, streams and runoff). Analysis focused on common biotic and abiotic water quality measurements that could be impacted by project actions. These include changes in hydrology, water chemistry, turbidity, and microbial communities.

Impacts would be considered short-term if effects would occur only during implementation of project activities and long-term if effects would occur beyond the duration of the project activities. The duration of the impact considers whether the impact would be temporary and/or associated with transitional types of activities or if the impact would occur over a longer period and alter long-term surface water quality.

Table 26. Water Quality Impact and Intensity Descriptions

Impact Intensity	Intensity Description
Negligible	Impacts would be very slight and, if detectable, highly localized. No impacts are expected to occur to water quantity, water temperature, dissolved oxygen, or pH. A slight, localized increase in turbidity may occur during piscicide treatments, barrier construction, and boat operations in shallow water. A slight, localized increase in specific conductance may occur due to potassium permanganate application.
Minor	Impacts would be measurable and could affect a small area of the watershed. The impact would be measurable or perceptible but slight, and could affect one or more water quality parameters but would not exceed federal or state water quality standards. Changes to water quality and quantity would be considered short-term.
Moderate	Impacts would be measurable and long-term, and would affect a sizable area of the watershed. This impact would be sufficient to cause a measurable deviation from baseline water quality and water quantity measurements; mitigation measures would be needed to avoid exceeding federal or state water

	quality standards for one or more water quality parameters. An action would have a clearly detectable effect on water quality standards and aquatic organisms.
Major	Impacts are readily measurable and have permanent consequences which could not be mitigated for a large portion of the watershed or extend beyond the watershed. The impact would be substantial and highly noticeable. Aquatic plant and animal species would disappear permanently, with species changes occurring on a regional scale. The action would result in a detectable change in aquatic plant and animal communities throughout the region.

Short-term— Short-term impacts to water quality and quantity would last only during the implementation of the projects, including their mitigation and monitoring measures.

Long-term— Long-term impacts would constitute a permanent impact.

Impacts of Alternative A: No Action on Water Quality

The impacts on water quality associated with the current program are the physical removal of nonnative fish prior to restoration in the remaining three basins through 2017. While electrofishing, crews would be walking within streams, which has the potential to disturb sediments. Where the substrate is heavy gravel, cobble, and bedrock, there is no effect. If stream substrate is silt, sand, light gravel, and organic debris, sediments may become suspended within the water column during and after electrofishing sessions. This would result in a localized release of fine material. Under certain conditions, large amounts of suspended solids can increase turbidity, attenuate sunlight, create biological oxygen demand, and alter downstream habitat by covering larger substrates (Dodds and Whiles 2010). However, these conditions typically occur at larger scales associated with anthropogenic land use changes (i.e. urban development, logging), or outstanding natural events (i.e. landslides, floods). Disturbance of sediments during electrofishing would be minimal, and likely less than what is caused by recurring natural processes. Therefore, electrofishing would have a short-term, negligible adverse effect on water quality.

While gill netting in waters, crewmembers wear waders and float on the surface of the water in a float tube or raft. Occasionally, flip fins used to guide the flotation device can disturb sediments in shallow areas. Gill nets make contact with the substrate when the net is dropped down. Gill nets are not dragged across the substrate. Thus, disturbance of sediments during gill netting is minimal and localized and gill netting would have a short-term, negligible adverse effect on water quality.

Cumulative Effects – Alternative A – Water Quality

There are few projects occurring in the wilderness that have a detectible effect on water quality. There could be overlapping projects or other actions that have localized effects on water quality. There could be short-term effects from trail projects and the use of stock near water resources. Bridge maintenance activities could affect water quality on a localized basis. Generally best management practices (BMPs) prevent more than minimal impacts from occurring. Trail maintenance projects probably would not occur in the same area as any proposed project activities; however they could occur in the same stream/river system/watershed.

Visitor use management is structured to reduce potential impacts to water quality by focusing on minimum impact practices. While there could be some effects to water quality from visitors or stock users camping too close to a waterbody, generally areas where people camp are away from areas where project activities take place in all alternatives. The incremental effect contributed by the alternatives to the overall cumulative effect would be such a small increment that it is impossible or extremely difficult to discern.

Overall, the incremental effect contributed by the no action alternative to water quality, when compared with ongoing operations, while evident and observable, would be relatively small in proportion to the overall cumulative effect. Therefore the cumulative effect would be short-term negligible and adverse.

Conclusion: This alternative would have short-term, negligible adverse effects on water quality due to slight increases in turbidity during project work. There would be no change to the beneficial uses of affected water bodies. The cumulative effects would be short-term negligible and adverse.

Impacts from Elements Common to All Action Alternatives on Water Quality

Crew camps: Crew camps would be established near project areas. Generally, the crew camps would be located at least 200 ft (60 m) away from waters. Crews would camp in these locations for 10-day shifts, up to 7 times per season, for up to 10 seasons depending on the treatment type. Typically crews utilize the camps for 4 to 6 seasons; occasionally it can be up to 10 seasons. While every effort would be made to avoid impacts to water quality, there is a slight potential for upland sediment, food and personal care items, and biodegradable soap to reach nearby waterways. Dish water is kept over a 100 ft (30 m) from water and is usually much further when the terrain permits. Latrine sites are normally at least 300 ft (91 m) or more from water in the deepest and/or richest (in organic matter) soils in the camp area. Crew members bathe at least 100 ft (30 m) from the water. Vegetation buffers and riparian areas adjacent to nearby waterways would greatly reduce the impact of crew camps.

Conclusion: Crew camps would have a negligible impact on water quality.

Use of Helicopter and Stock: Water quality would not be adversely affected by the use of helicopters. Helicopter landing zones are typically placed on granite slabs or flat gravel areas away from water. Therefore, helicopters would have no effect on water quality.

The use of stock to transport supplies could adversely affect water quality. Stock would travel on trails to the project sites, and could travel cross country if deemed appropriate, avoiding sensitive areas such as wet meadows. Stock may kick up sediments when crossing streams along trails, therefore increasing small sediment materials into park waters. However, this effect would be localized and many park trails are engineered to minimize this impact. Stock may cause more impact when grazing meadows and riparian areas of adjacent waters (Belsky et al. 1999). Grazing and subsequent trampling of these areas could result in stream bank erosion and sediment disturbance. Because excessive grazing in meadows can decrease vegetation cover and biomass, which in turn, increases soil exposure (Cole et al. 2004) and subsequent runoff of exposed soil in overgrazed areas can increase fine sediment into nearby waterways, packers would be required to use supplemental feed (e.g., cubes or grain) in sensitive areas.

Stock can increase nutrients and harmful microbes (e.g. bacteria, virus, protozoans) in waterways through defecation and urination. In meadows and wetlands, excess nutrients may be taken up by the vegetation, potentially increasing primary production at a localized level. In streams and lakes, increases in excess nutrients could cause algal blooms (Dodds and Whiles 2010). Algal blooms from stock associated with this project are unlikely, but this phenomenon has never been measured in SEKI. Water quality impacts due to solid animal waste may contain harmful protozoa such as *Giardia lamblia* and *Cryptosporidium* spp., and coliform bacteria such as *Salmonell*a spp. Levels of fecal bacteria in SEKI are generally low, though natural sources often contribute to higher concentrations during runoff events (NPS 1983, Clow et al. 2013). While harmful microbe contributions from visitors and stock are not well known, Clow et al. (2013) found the lowest frequency of fecal coliforms in areas with the least human use and higher frequencies in areas used by pack animals.

Conclusion: There would be no effect on water quality from helicopter use. Since project stock support would be a small percentage of overall park stock use (see description in "Elements Common to All Action Alternatives"), and mitigation measures as detailed in chapter 2 would be implemented, along with normal administrative best management practices, the impact to water quality would be negligible to minor and adverse. In the long term, as stock is no longer needed in project areas, there would be no effect.

<u>Restoration of Mountain Yellow-Legged Frogs, Monitoring, and Continuing Research:</u> At any given time within the parks, other aspects of the restoration program would be ongoing. At currently fishless sites, and in areas rendered fishless by implementing this plan (up to 55 basins depending on the alternative selected), restoration of the ecosystem could include natural recolonization, reintroduction of native species, and/or a combination of the two. There would also be continuing science and monitoring as part of this project which would involve the presence of researchers and could involve netting, tagging, and other activities in project areas. Water quality could be slightly adversely affected by the presence of researchers from walking around the shoreline of project waterbodies, which could cause localized trampling of riparian vegetation, and walking in the water during project work, which could increase turbidity on a localized basis.

Conclusion: Overall, the short-term effects from the restoration, monitoring, and research program would be negligible to minor and adverse, but the long-term effects would be beneficial as healthy functioning native ecosystems are restored.

<u>Fish Disposal:</u> Typically, nonnative fish that are removed by gill-netting and electrofishing from current and proposed treatment areas are sunk to the bottom of fish-removal lakes. This allows the fish to decompose, releasing the nutrients back into the local ecosystem. Small numbers of fish removed by electrofishing are occasionally sunk in fish-removal streams. This onsite decomposition process is important because the parks' high elevation aquatic ecosystems are oligotrophic environments, meaning they naturally have low nutrient levels for sustaining life (Sickman and Melack 1992, Dodds and Whiles 2010). The energy contained in populations of nonnative fish, which often number in the thousands of fish, are released back to the native ecosystem to avoid the loss of those valuable nutrients. For physical treatments, fish are sunk as they are gradually caught over 2 to 4 years until eradication is achieved. This allows decomposition to be spread out over time. For piscicide treatments, most or all of the fish are expected to be killed immediately, causing a substantial pulse of dead fish back into the project area.

Disposing fish back into the treatment lakes would locally increase nitrogen (N), phosphorus (P), and dissolved organic carbon (DOC; Premke et al. 2010). It is unknown how long N, P, and DOC would be elevated in these lakes, but some influence is expected to persist after restoration as the fish are incorporated into the sediments, or periodically released during lake mixing. Excess nutrients in some environments have the potential to increase phytoplankton biomass, causing algal blooms that affect lake water clarity and oxygen availability (Dodds and Whiles 2010). Lakes in the project area generally mix twice each year, and water residency time is generally short (Sickman et al. 2003). Therefore, a combination of mixing and flushing events would periodically flush project lakes of nutrients. Once nonnative fish are removed, large zooplankton grazers return to restored lakes (Knapp et al. 2001). These animals are effective at controlling phytoplankton growth (Brooks and Dodson 1965), so recovery of zooplankton communities is expected to reduce the effect of increased phytoplankton growth from the increase in nutrients. Dead and decomposing fish can also increase bacteria levels. This would likely be localized to shallow areas and residual pools. As with excess nutrients, seasonal hydrology is expected to flush waters of elevated bacteria levels. If it is estimated that large scale fish removals from piscicide use have the potential to cause prolonged eutrophic conditions and elevated bacteria in treatment lakes based on fish densities, lake morphology, and water retention times, project managers would consider alternatives to sinking all of the dead fish. These may include (1) disposing of some fish in non-treatment lakes within the treatment basin; and (2) spreading fish in upland areas for decomposition. Given the oligotrophic (nutrient lacking) conditions, cool water temperatures, and seasonal flow variability in the high elevation aquatic ecosystems, any long-term eutrophication is expected to be very unlikely.

Conclusion: Impacts of fish disposal on water quality would be short term negligible to moderate and adverse based on the type of operation (whether gill netting or piscicide use) and the timing (more fish are caught during the early stages of the treatment).

Cumulative Effects from Elements Common to All Action Alternatives – Water Quality

There are very few projects occurring in the wilderness of SEKI that have a detectable effect on water quality. There may be some overlapping studies that would occur in the same area/watersheds as the proposed project. There could be a slight effect on water quality from this work as a result of trampling around the shoreline leading to increased turbidity. However, these studies would not result in measureable effects to water quality and these impacts would be imperceptible.

There could be short-term effects from trail projects and the use of stock near water resources. Bridge maintenance activities could affect water quality on a localized basis. Generally best management practices (BMPs) prevent more than minimal impacts from occurring. Trail maintenance projects probably would not occur in the same area as any proposed project activities; however they could occur in the same stream/river system/watershed.

Visitor use management is structured to reduce potential impacts to water quality by focusing on minimum impact practices. While there could be some effects to water quality from visitors or stock users camping too close to a waterbody, generally areas where people camp are away from areas where project activities take place in all alternatives. The incremental effect contributed by the alternatives to the overall cumulative effect would be such a small increment that it is impossible or extremely difficult to discern.

Overall, when considering the actions common to all alternatives and other projects that could affect water quality, the cumulative effects would be short term negligible and adverse.

Impacts of Alternative B: Prescription Treatment Preceding Restoration (Preferred Alternative) on Water Quality

The impacts on water quality from gill-netting and electrofishing would be the same as described under alternative A, but would occur in an additional 52 waterbodies (27 lakes, 24 ponds, 1 marsh; total of 492 ac/199 ha) and approximately 15 mi (25 km) of streams in 17 basins.

Fish would also be removed from additional waterbodies using a piscicide (rotenone) and an oxidizer (potassium permanganate). The impacts to water quality from piscicide treatments would occur in 33 waterbodies (4 lakes, 25 ponds, 4 marshes; total of 142 ac/57 ha) and approximately 16 mi (25 km) of streams in 9 basins. These impacts would occur to surface water quality, piscicide treatment is not expected to affect ground water.

Surface water quality parameters have the potential to be altered directly or indirectly by the use of piscicides. Individual piscicide treatments would normally be applied to small areas in order to minimize the size of the affected area, but not so small that treatment is unnecessarily prolonged. The minimum size treatment area must include a definitive fish barrier (e.g. large waterfall) to prevent post-treatment reinvasion of fish inhabiting downstream areas. Most treatments during any given year are expected to involve less than one to several miles of stream and/or one to several lakes. Some years may receive no piscicide treatments due to pretreatment planning. Depending on environmental conditions (e.g. solar exposure, lake depth, wind, pH, etc.), most of the chemicals would break down in several days to several weeks in water, and several weeks to several months in sediments (Finlayson et al. 2001, CDFW 2007, Vasquez et al. 2012). Stream water would be detoxified at the lower end of the treatment site using potassium permanganate.

Rotenone formulations typically use a hydrocarbon solvent to aid in the mixing of rotenone with water. Potassium permanganate is used to neutralize the piscicide and is purple in color. Rotenone associated hydrocarbon solvent would temporarily impact water quality because detectable levels of rotenone and potassium permanganate would have short-term persistence in treated waterbodies. Both piscicide and potassium permanganate applications would reduce water clarity and contribute new chemical components to stream systems for the application period and in the short-term following application.

Rotenone is highly toxic to trout (LC50 = 1.94 ppb) while having low toxicity to humans (EPA 2007A). Rotenone is not known to pose a long-term threat to surface or groundwater quality (EPA 2007A). As a result, piscicide application would cause direct, short term minor to moderate and adverse impacts on stream and lake water quality in the area being treated. As a result of these impacts, human consumption of water within treatment areas, and approximately one-half mile downstream of the rotenone neutralization station would be restricted during and immediately after treatment in accordance with EPA rotenone label guidelines. Further information concerning piscicides can be found in the Health and Safety section later in this chapter, Appendices G and H, and the piscicide product label outlining human use of treated water found in appendix H. Physical fish removal methods would use gill netting and electrofishing to capture and remove nonnative fish. Physical fish removal would require working directly within a stream or lake which would cause sediments to temporarily become re-suspended and reducing water clarity. These activities would lead to direct short-term minor adverse impacts on water quality.

During the 2007 Lake Davis rotenone treatment by CDFW, five of the major rotenone mixture ingredients—rotenone, rotenolone, methyl pyrrolidone, diethylene glycol monethyl ether (DEGEE), and Fennedefo 99—were measured in surface waters, sediments, and rotenone-resistant catfish. Depending upon the ingredient, the half-life values ranged from 6 to 14 days in water, 0 to 49 days in sediment, and 6 to 13 days in catfish. Among all sampling media (water, sediment, catfish), concentrations declined rapidly within two days of piscicide treatment, and no compound was detected 212 days post treatment (Vasquez et al. 2012). During the 2006 Diamond Lake rotenone treatment by Oregon Department of Fish and Wildlife, rotenone and its breakdown product rotenolone rapidly degraded within 2 days, largely because pH and temperatures were elevated (Finlayson et al. 2014). In this instance, both compounds completely dissipated in water within 46 days. Both were also never detected in groundwater, lake sediments, and aquatic plants (Finlayson et al. 2014).

The proposed rotenone treatments would likely differ from these recent examples, making specific determinations of fate and transport undetermined until detailed site analysis is completed soon before any approved piscicide applications. However, it is expected that that the proposed sites would have greater heterogeneity in habitats, lower pH, greater dissolved oxygen, colder waters, and summer lake stratification (Finlayson et al. 2000). All of these features could extend rotenone persistence in the environment. However, montane stream systems are often turbulent and well-mixed, which helps increase the breakdown and dissipation of rotenone (Finlayson et al. 2010A). These features are common among montane habitats, and concentrations in streams would likely still be well below any human or wildlife health risk within days of the treatment (EPA 2007A, Brown and Zale 2012, NPS 2013B).

While persistence in the environment varies and is site-specific, the rotenone formula has not been detected in repeated groundwater sampling efforts (Finlayson et al. 2001, CADHS 2007, Finlayson et al. 2014). This has alleviated drinking water concerns in areas close to rotenone treatments. For those individuals planning to drink surface waters in SEKI wilderness within the treatment area, there would be cautionary water consumption warnings posted at treatment areas (see mitigations in chapter 2; and appendix N). However, consumption warnings would not be necessary in the vast areas outside of the treatment area. Any movement of rotenone ingredients past the potassium permanganate neutralization station are expected to dissipate and degrade in the environment faster than within the treatment area due to dilution (Brown and Zale 2012). In regard to the detoxification process with potassium permanganate, this process would only take place in streams that drain lakes treated with rotenone, and detoxification procedures would vary depending on water temperature, lake depth, the amount of inlet and outlet flow, and the amount of dilution that occurs in the streams as they travel through the watershed.

Stream treatments with potassium permanganate to detoxify rotenone would likely have an adverse impact on aquatic organisms from the neutralization station to 30 minutes of travel time downstream of the station (Marking and Bills 1975, Hobbs et al. 2006). This area would be considered part of the affected treatment area for the project, and fish as well as non-target organisms would be monitored in this area. Potassium permanganate does not travel long distances downstream and is not persistent in the environment because it is quickly reduced through natural processes (FWS 2010). While potassium permanganate could be toxic to terrestrial organisms at high concentrations, the chemical is routinely used to treat potable water supplies for oxidizing contaminants, colors, and odors (Tucker and Boyd 1977, Chen and Yeh 2005, Dash et al. 2009), and would not amount to those levels within the proposed action. The impacts are likely to be very limited in scale because potassium permanganate would quickly react with (oxidize) a wide variety of substances once introduced into the environment (Dash et al. 2009). The high degree of reactivity limits its capacity to travel downstream in concentrations that could prove harmful to aquatic or terrestrial life (see "Health and Safety" in chapter 4; appendix G).

Dissolved oxygen

Dissolved oxygen (DO) is a biologically important compound found in water (Dodds and Whiles 2010). It is a necessity to many aquatic organisms, including amphibians, fish, and many invertebrates. Rotenone application could reduce DO concentrations by causing increased chemical oxygen demand (CDFW 2007). As rotenone degrades, oxidation can reduce DO for up to 3 weeks, depending on the habitat and water temperatures. Colder water holds more DO than warmer water (Dodds and Whiles 2010) and thus can offset reductions in DO concentrations caused by rotenone more effectively than warmer water.

Piscicide treatments would be planned when water depths and discharge are lowest (late summer). During this time, warmer water temperatures can further reduce DO. These conditions could create a short-term impact on recolonizing invertebrates that rely on DO saturated waters. However, although water temperatures would be in a seasonally warm phase, they would still be relatively cold (~60°F / 16°C) due to the high elevations of the project area, and thus slight DO reductions would be expected from rotenone treatment. In addition, treatment streams with shallow riffles and cascades would rapidly reoxygenate treated water, and thus any reduction in DO would be quickly offset by these natural oxygenation processes. Therefore, since DO reductions would likely be slight in magnitude and short in duration, project work would have a short-term, minor adverse impact on DO levels.

In addition, there is a slight potential for fish decomposition to change DO levels. Temporary increases in bacterial oxygen consumption following large numbers of dead fish entering the system in a short timeframe would likely result in decreased DO levels. However, the effects from this potential drop in DO are expected to be short term. The cold, well-mixed high elevation aquatic ecosystems in which restoration actions are taking place would likely be less affected by temporary declines in DO, since most of these cold water systems have high DO levels, and oligotrophic conditions results in less biotic DO demand than more biologically productive systems found at lower elevations. Additionally, North Cascades National Park has been conducting piscicide treatments in which fish killed remain in the system, with no negative effects observed resulting during five years of treatments (Rawhouser, A., pers. comm., 2016). Additionally, with physical fish removal methods from approximately 23 lakes and ponds treated since 2001, SEKI staff, who are onsite during the entire treatment period, have not observed any animals being affected by fish decomposition (i.e. zooplankton, invertebrate, or tadpole die-offs). Although fewer fish are killed at one time during the use of physical methods when compared with piscicide treatments, large numbers of fish (e.g., hundreds of fish) often enter a given waterbody during the first several days of gill netting efforts (NPS unpublished data).

Turbidity
Turbidity would be increased during applications of rotenone and potassium permanganate. Applications and temporary change in water color can attenuate light, which would increase turbidity (NPS 2006B). Any increases in turbidity would be localized short term minor and adverse.

Acidity
Acidity is the ability of a solution to react with a base, and is measured using the proton ion concentration (pH). The direct use of piscicides is not expected to impact pH (CDFW 2007), however naturally occurring conditions could accelerate degradation of rotenone (Finlayson et al. 2000). High pH (>9.0) waters degrade rotenone faster than the more acidic (< 9.0 pH) waters found in the project area. Additional rotenone treatment may be required in the most acidic project areas, but initial applications would take site specific characteristics and adjust rotenone concentrations accordingly. Since rotenone would not alter pH from pre-treatment conditions, there would be no effect on acidity.

Dissolved Ions
Conductivity of water is highly dependent on dissolved ions present. Therefore, measuring conductivity can detect changes in dissolved ion concentrations. The direct use of piscicides is not expected to impact conductivity (CDFW 2007). There is a small chance that conductivity would be affected by potassium permanganate due to its ionic nature (NPS 2006B). Therefore, there would be no effect on conductivity from rotenone and a short-term, minor adverse effect to conductivity from potassium permanganate.

Bacteria
Following piscicide treatment, the decomposition of dead fish in large numbers may result in temporarily elevated bacteria levels in the water, particularly in pools or backwater areas where carcasses may collect. However, fish decomposition is not anticipated to be a public health concern (Luckett 2015). The primary ecological concerns related to fish decomposition would be the potential for temporary nutrient loading and algal growth following the pulse of nutrients returning to the ecosystem. Several environmental factors would likely mitigate these effects, including cool water temperatures, oligotrophic conditions, and seasonal mixing of lakes, which allow nutrients and possible bacterial loads to be quickly flushed from the treatment area.

Cumulative Effects – Alternative B – Water Quality

As described under alternative A, there are few projects occurring in the wilderness of SEKI that have measurable and long-term adverse effects on water quality. There could be overlapping projects or other actions that have localized and short-term effects on water quality from increased turbidity due to shoreline and in water trampling. There are no other projects planned that would utilize piscicides in the waters of the parks. Overall, the cumulative effects would be short term negligible and adverse.

Conclusion: Physical treatments would result in no effect to short-term, negligible adverse effects on water quality. Piscicide treatments would result in short-term minor adverse effects on water quality. Based on the above analyses, there would be a slight and short term effect on the beneficial uses of the water bodies treated with piscicides, but no long-term change. This slight temporary effect is consistent with the maximum benefit of the people of the State of California by promoting the recovery of an endangered species. This project is consistent with the antidegradation provision of 40 CFR section 131.12 and California Resolution 68-16.

Impacts of Alternative C: Physical Treatment Preceding Restoration on Water Quality

The impacts to water quality from gill-netting and electrofishing would be the same as described under alternative A, but would occur at an additional 52 waterbodies (27 lakes, 24 ponds, 1 marsh; total of 492 ac/199 ha) and approximately 15 mi (25 km) of streams plus connected fish-containing habitat as necessary in 17 basins. Turbidity would also increase during blasting activities but this effect would occur just after the blasting operation and would dissipate quickly.

Cumulative Effects – Alternative C – Water Quality

This alternative is similar to alternative A. There are few projects occurring in the wilderness that affect water quality. There could be overlapping projects or other actions that have localized effects on water quality from increased turbidity from project crews walking in the water or along the shoreline. However, the incremental effect contributed by the no action alternative to water quality, when compared with ongoing operations, while evident and observable, is still relatively small in proportion to the overall cumulative effect. Therefore the cumulative effect would be short term negligible and adverse.

Conclusion: Physical treatments would result in *no effects to short-term, negligible effects* on water quality. Based on the above analyses, there would be no effects on the beneficial uses of the water bodies This alternative is consistent with the maximum benefit of the people of the State of California by promoting the recovery of an endangered species. This project is consistent with the antidegradation provision of 40 CFR section 131.12 and California Resolution 68-16.

Impacts of Alternative D: Piscicide Treatment Preceding Restoration on Water Quality

This alternative would be similar to the piscicide treatment portions of alternative B, except piscicide treatment would occur in all 85 waterbodies (31 lakes, 49 ponds, 5 marshes; total of 634 ac/257 ha) approximately 31 mi (50 km) of streams, plus connected fish-containing habitat as necessary, in 21 basins. Therefore, impacts from piscicide use would occur at more basins, but the impacts to water quality from piscicide use would be the same as described under alternative B.

Cumulative Effects – Alternative D – Water Quality

As described previously, there could be a few overlapping projects or other actions that have localized effects on water quality from increased turbidity. There are no other projects planned that would utilize piscicides in the waterbodies of the parks. Overall, the cumulative effects would be short term negligible, and adverse.

Conclusion: Piscicide treatments would result in short-term minor adverse effects on water quality. The cumulative effects would be short term negligible and adverse. Based on the above analyses, there would be a slight and short term effect on the beneficial uses of the water bodies treated with piscicides, but no long-term change. This slight temporary effect is consistent with the maximum benefit of the people of the State of California by promoting the recovery of an endangered species. This project is consistent with the antidegradation provision of 40 CFR section 131.12 and California Resolution 68-16.

WILDERNESS CHARACTER

METHODOLOGY FOR ANALYZING IMPACTS

Most of the sites within the proposed project area are in designated wilderness. Working from definitions included in the *Wilderness Act of 1964*; and *Keeping it Wild: An Interagency Strategy to Monitor Trends in Wilderness Character Across the National Wilderness Preservation System* (Landres et al. 2008), and following the tradition of wilderness preservation at SEKI, the following wilderness resource values have been identified for the parks and are a component of its wilderness character. The USFS national framework for monitoring wilderness character (Landres et al. 2005) concluded that wilderness character is ideally described as the unique combination of (a) natural environments that are relatively free from modern human manipulation and impacts, (b) opportunities for personal experiences in environments that are relatively free from the encumbrances and signs of modern society, and (c) symbolic meanings of humility, restraint, and interdependence in how individuals and society view their relationship to nature. The following are considered the five qualities of wilderness character:

Untrammeled: Wilderness is essentially unhindered and free from modern human control or manipulation. Trammeling is an action by humans to intentionally manipulate the natural elements of wilderness.

Natural: Wilderness ecological systems are substantially free from the effects of modern civilization, and are protected and managed to preserve their natural conditions.

Undeveloped: Wilderness retains its primeval character and influence, and is essentially without permanent improvement or modern human occupation, where humans are a visitor who does not remain.

Providing Outstanding Opportunities for Solitude or Primitive and Unconfined Recreation: Wilderness provides outstanding opportunities for solitude or primitive and unconfined experiences, and promises the following:

The likelihood of not encountering other people while in wilderness, including privacy and isolation.

The absence of distractions (such as large groups, mechanization, unnatural noise, signs, and other modern artifacts).

Freedom from the reminders of modern society.

The freedom of visitors to explore, with limited or no restrictions; the ability to be spontaneous.

Self-sufficiency and absence of support facilities or motorized transportation; direct experience of weather, terrain, and wildlife with minimal shelter or assistance from devices of modern civilization.

Other Features of Value: Wilderness may have other unique features of value, including cultural resources and landscape, ethnographic values, scenic resources, and opportunities for science and education. Since there would be no measurable effect on other features of value, this impact topic is dismissed from further analysis.

Impacts on natural resources; science; parks, recreation, and visitor use; and soundscapes are evaluated elsewhere in this section (Environmental Consequences of the Alternatives). The analysis for this topic focuses on wilderness character (Table 27). In addition, a minimum requirement analysis is included as appendix A.

Table 27. Wilderness Impact and Intensity Descriptions

Impact Intensity	Intensity Description
Negligible	There is little or no change to the five attributes of wilderness character.
Minor	One or more attributes of wilderness character change but the changes are temporary and occur in small ways in one or more locations.
Moderate	One or more attributes of wilderness character change in substantial ways in a single distinct area, or it affects multiple areas but is not permanent.
Major	One or more attributes of wilderness character changes substantially across more than one distinct area on either a permanent or frequent but temporary basis.

Short-term—effects occur during project work per specific treatment locations.

Long-term—effects occur after project work at each treatment location is completed, and would continue to impact wilderness resources in the future.

Impacts of Alternative A: No Action on Wilderness

Untrammeled: Under this alternative, there would continue to be trammeling actions until the current restoration project is completed. Habitat in three basins would be actively restored until eradicated of fish, expected by 2017. Trammeling actions include gill netting and electrofishing to remove nonnative fish from the lakes and streams within the project area.

Natural: Under this alternative, there would be a slight change on the natural quality of wilderness as the restoration program continues through 2017. If the program continues to be a success, the natural ecosystem would be restored in 25 park waterbodies, totaling less than 5% of the 575 waterbodies that contained nonnative fish prior to the start of research-led eradications in 1997 and park-led eradications in 2001.

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 due to 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 amphibian 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 would continue to be long-term major and adverse.

Undeveloped: Under this alternative, the undeveloped quality of wilderness is adversely affected by the installation of gill nets, the presence of crew camps, and the use of helicopters. The existing program requires use of gill nets in the current 10 treatment waterbodies contained in 3 basins in the wilderness, with completion expected by 2017. Gill nets are deployed and left in the lakes for several hours to several days, and can be deployed over the winter months. The crew camps generally include food storage lockers which remain in place for the duration of the project work (through 2017). Helicopter flights would be used to transport heavy and sensitive equipment to the project locations that cannot be accessed by stock. These developments have a short- to long-term adverse effect on the undeveloped quality of wilderness, but there would be no permanent change to the undeveloped quality of wilderness under the no action alternative.

Opportunities for Solitude or Primitive and Unconfined Recreation: Under this alternative, there would be long-term minor adverse effects on opportunities for primitive and unconfined recreation resulting from the loss of angling opportunities at the treated lakes. There would continue to be angling opportunities at 550 waterbodies that contain nonnative fish. There would be long-term beneficial effects on opportunities for primitive recreation (e.g. wildlife viewing) resulting from the eradication of a nonnative fish from up to 25 park waterbodies and the potential natural recolonization by MYLFs and restoration of healthy native ecosystems at these sites.

Work crews would be present in the wilderness during summer months through approximately 2017 and monitoring crews could be present indefinitely to monitor the ongoing restoration program. Crews are small (two to three members), and located in remote areas generally away from trails. There is the chance that a wilderness visitor could view the work crews or camps, and thus their solitude would be affected. However, the crews are small in size and this effect would be no different than visitors encountering other visitors in the wilderness.

The use of helicopters would reduce opportunities for solitude as it would affect the natural soundscape on a short-term basis affecting opportunities for solitude on the flight path and at the project sites. 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.

Cumulative Effects – Alternative A - Wilderness

For the purposes of evaluating cumulative effects to wilderness, since the project work would occur deep within the wilderness of SEKI, and be very unlikely to affect neighboring wilderness values and character, the cumulative effects analyses for wilderness character focuses on the wilderness areas within SEKI.

One of the most substantial past actions that has adversely affected wilderness throughout the Sierra Nevada is nonnative fish stocking. Under the no action alternative, self-sustaining nonnative trout populations would remain in 550 waterbodies plus connecting streams contained in 88 basins. These waterbodies 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 into the foreseeable future.

Other past, present, and future actions that may affect wilderness resources and character within SEKI includes park administrative activities (e.g. resource management and research projects; Sierra Nevada bighorn sheep management; ranger and maintenance activities; emergency actions; and projects where helicopter flights have been determined to be the minimum requirement for administering the area as wilderness). Existing project work, whether it is resource management, science-related, operational work such as trail maintenance, or the presence of existing facilities, can affect elements of wilderness character.

Activities such as helicopter use can affect the undeveloped quality of wilderness character, and opportunities for solitude. Each year the parks conduct flights in wilderness for administrative purposes. There are additional flights for emergencies, including fires, search and rescue operations, and law enforcement operations. The number and location of the emergency flights are extremely variable. Few flights would occur as part of the no action alternative, there would be short-term minor adverse cumulative effects to the undeveloped element or solitude of wilderness character as a result of additional helicopter flights.

On-going and future projects which include the intentional manipulation of the natural system include translocating Sierra Nevada bighorn sheep and removing invasive or nonnative vegetation. There are planned translocations of Sierra Nevada bighorn sheep into unoccupied historic range over the next ten years. This would result in short-term adverse effects on the untrammeled quality when the translocations are occurring, resulting in long-term beneficial effects on the natural quality from the recovery of the species.

The control of invasive nonnative plant species results in an adverse effect on the untrammeled quality of wilderness character. Prior to 2001, invasive nonnative plant management in SEKI was conducted on an ad-hoc basis by park staff and volunteers. In 2001, the parks initiated a comprehensive restoration and invasive plants management program. The goals of the invasive plant management program are to prevent new populations of invasive plants from establishing in SEKI and to control or eradicate existing high priority populations, resulting in desirable plant communities and healthy ecosystems. Native intact communities have the highest priority for management, while highly altered communities such as foothills grasslands have a lower priority. The program involves prevention, early detection, and rapid response to invasive plant outbreaks.

In wilderness, several methods are used to control invasive plants. Manual (hand-pulling, hand-digging) and tarping (placing black fabric over the infestation for 1 to 2 years) are generally attempted initially and are the preferred methods in wilderness. However, larger infestations, or those plants that are known to be resistant to hand pulling and tarping, or where past manual efforts were unsuccessful may be treated with an herbicide (e.g. glyphosate, clopyralid, or rimsulfuron) using backpack sprayers. Timing of treatments is generally March to November; several treatments may be required during the season, depending on the plant species. A helicopter could be utilized in certain situations for removing tarps from wilderness upon project completion, and stock use could also support invasive plants control operations. While the invasive plants program has short-term adverse effects on the untrammeled and undeveloped elements of wilderness character, and can reduce opportunities for solitude in areas where crews are present, in the long-term, this program restores and protects the natural quality of wilderness character by preventing the spread of invasive plant species and restoring native plant species resulting in long-term beneficial effects.

The placement of equipment, associated with science and resource management activities, can affect the undeveloped quality of wilderness. Between 60 and 90 research permits are authorized each year in SEKI, many of these in wilderness. Some require temporary installations, which adversely affects the undeveloped qualities of wilderness in localized areas. The presence of field scientists can also reduce opportunities for solitude, but generally no more than an average visitor encounter. Science can lead to better decisions and improved resources management in wilderness, resulting in long-term beneficial effects on the natural qualities of wilderness character.

The presence of work crews associated with administrative activities such as trail maintenance reduces opportunities for solitude. In Sequoia National Park, there are typically five trail crews working each season. There are three maintenance crews of four to five members and one construction crew of seven to nine members. These crews work from June to September in the wilderness. During the spring season there is typically one crew of four to eight members working in the lower elevation wilderness areas. In Kings Canyon National Park, there are typically three NPS crews with four to six people including a packer for support, and one large NPS Civilian Conservation Crew (CCC) (18 to 24 people including the packer). From approximately 2011 to 2014 a crew of three to four people reconstructed three ranger stations. Crews work front country and nearby adjacent wilderness until early June, then have a more remote wilderness season through the end of September, after which the crews transition back to the front country. Work crews adversely affect the undeveloped quality of wilderness when they use mechanized tools, and reduce opportunities for solitude by their presence at work sites. Trail crews also reduce opportunities for primitive and unconfined recreation by maintaining trail corridors that allow for visitor use, though some may argue that this work enhances opportunities for primitive and unconfined recreation by providing access into the wilderness. The presence of well-maintained trails can improve the natural conditions of wilderness by protecting resources (native plants), and by preventing erosion and adverse impacts from visitors going around damaged sections of trails, and can result in long-term beneficial effects on wilderness character.

Overall, the no action alternative, when considered with past, present, and future potential activities, adds to existing adverse effects on the untrammeled and undeveloped elements of wilderness character, and slightly reduces opportunities for solitude and primitive and unconfined recreation in two to three areas of the wilderness during project activities. It would improve the natural quality of wilderness character by restoring native ecosystems in 25 waterbodies and 3.7 mi (6.0 km) of streams (contained in seven basins) through approximately 2017, but most of the waterbodies in the SEKI and adjacent wilderness lands would continue to support nonnative trout. The cumulative impacts would be adverse and moderate for three qualities (untrammeled, undeveloped, and opportunities for solitude or primitive and unconfined recreation). Cumulative effects on the natural quality would remain adverse across the Sierra Nevada, but would improve slightly as native ecosystems are restored.

Conclusion: Over the life of the project (through approximately 2017), there would be 25 waterbodies (16 lakes and 9 ponds totaling 161 ac/65 ha) and approximately 3.7 mi (6.0 km) of streams contained in 7 basins treated by physical methods (e.g. gill netting and electrofishing). Fifteen of these waterbodies are already completed and 10 are nearly completed. Under this alternative, self-sustaining nonnative trout populations would continue to exist in 550 high elevation waterbodies plus connecting streams. The treatment activities constitute a short-term moderate adverse effect on the untrammeled quality of wilderness through 2017. There would be a short-term adverse effect on the undeveloped quality from the installation of gill nets, equipment/food storage lockers, and the use of helicopters. There would be an adverse effect on solitude from the presence of crews and the use of helicopters and an adverse effect on angling opportunities.

There would be long-term beneficial effects on opportunities for wildlife viewing (i.e. primitive recreation) resulting from the eradication of nonnative trout from up to 25 waterbodies and the potential natural recolonization by MYLFs and restoration of healthy native ecosystems at these sites. There would be a long-term minor adverse effect on angling opportunities at the 25 waterbodies when all nonnative trout are removed. This alternative allows nonnative fish to exist and modify the ecosystem to the extent that some species may become extinct, perpetuating a long-term major adverse effect on the natural quality of wilderness character.

Impacts from Elements Common to All Action Alternatives on Wilderness

The following is the analyses of those elements common to all alternatives that could have an effect on wilderness character.

<u>Crew Camps:</u> Crew camps would be selected to minimize impacts to wilderness character. Generally camps would be away from popular visitor use areas and developed trails, and would be located on bare ground away from water. Crew camps would be located in wilderness up to 10 days per site visit, 7 times per season, and typically for a 5 to 7 year period for each physical treatment basin, but could last for up to 10 years at sites with long or complex streams.

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 would 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. Areas have been shown to recover after project work thus there would be no long-term effect on the natural from crew camps.

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 minor to moderate 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 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 be negligible to minor and short-to long-term (depending on the treatment type selected).

<u>Use of Helicopters and Stock:</u> Stock would be the preferred method for mobilization and demobilization to project sites, but helicopters would be used when specific conditions are met (See mitigation measures section of chapter 2). Where stock is utilized, stock would be used for two round trips per site, one to two sites per year. In general, site mobilizations require five animals and demobilizations require three to four animals. Consequently, maximum yearly stock use is estimated to be eight to nine 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. If a helicopter is determined to be the minimum tool, there would be one flight at the beginning of the season to each project location and one flight at the end of the season to each project location. In addition, helicopters may be used to transport essential biological material that is time sensitive or too fragile to be moved by stock (e.g. MYLFs that are being reintroduced into sites or diseased animals that need to be moved to a formal lab for analysis). It is anticipated that there would be zero to three flights per restoration site per year (there would be no flights required for those sites suitable for stock support).

Effects of Helicopter and Stock use on Untrammeled: There is no intentional manipulation of the wilderness from the use of helicopters and stock. Therefore there is no effect on the untrammeled quality of wilderness.

Effects of Helicopter and Stock use on Natural: Helicopters affect the natural quality of wilderness by causing disturbance and flight responses in wildlife. The level of disturbance varies depending on the species, and also depending on the habitat. Some animals temporarily leave an area and return when the disruption is gone (when the helicopter departs). Other animals may not return for an extended period (many hours to days) after the disruption ends. Helicopters near habitat may cause some animals to abandon nests or their young. Regardless, there is very little change overall to the natural element of wilderness, and the effects would be short-term, negligible to minor, and adverse. Stock can affect the natural quality of wilderness. Moist organic soils become muddier after stock pass through the area, and stock urinate and defecate on trails. Since the stock would only be used during mobilization and demobilization, no stock camps would be established as a result of these actions, and minimum impact techniques would be employed, the effects on natural would be minor and short-term.

Effects of Helicopter and Stock use on Undeveloped: There would be adverse effects on the undeveloped quality of wilderness from the transport of supplies to the sites if helicopters are the chosen method of transport. 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 in route and for 10 to 15 minutes at the landing areas, and would occur in several locations in wilderness each summer. The adverse effect on undeveloped would be short-term and minor to moderate.

Effects of Helicopter and Stock use on Opportunities for Solitude or Primitive and Unconfined Recreation: 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 10 to 15 minutes required to off load or load equipment, so the adverse effect would be negligible and short-term.

Some wilderness users consider pack stock to be an intrusion on their wilderness experience. Backpackers must step off trails for stock strings to pass, stock kick up dust on dry trails, and leave manure and urine. These conditions may be objectionable to some wilderness users, and could reduce opportunities for solitude on the trails into the project area, and at the project area itself. Again, since this effect would occur only at mobilization and demobilization, the effect would be temporary and minor.

<u>Restoration of Mountain Yellow-Legged Frogs:</u> Ecosystem restoration and management focuses on restoring native wildlife species including restoring MYLF populations to areas where they once occurred and protecting existing MYLF populations. This would occur within existing fishless areas, and areas that are proposed for fish removal under each action alternative. The goal would be the restoration of MYLFs in 55 basins, 34 of which are currently or soon-to be fishless. This would be accomplished by natural recolonization, reintroductions, or a combination of the two.

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 intentional manipulation of 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. Therefore, at any given time, for the next 20 to 35 years, there would be trammeling actions in various locations in the wilderness related to the restoration activities.

Effects of Restoration of Mountain Yellow-Legged Frogs on Natural: Restoration of a key species (MYLF) 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 (Knapp R., unpublished data). If ecosystem restoration is successful, there would be long-term beneficial effects on the natural element of wilderness character by restoring a 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 would be 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 or 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 minor to moderate and short- to 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 of Crew Camps" it is 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 for other wilderness users, thus the effect is negligible to minor and adverse.

Effects on primitive and unconfined recreation would differ depending on the type of recreational experience sought. 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 85 waterbodies contained in up to 21 basins. However, angling opportunities would remain available at the 465 waterbodies that currently contain fish. There would be no adverse effects on opportunities for primitive and unconfined recreation for wilderness travel since there would be no area closures related to this work. There would be long-term beneficial effects on primitive recreation related to viewing native wildlife and healthy native ecosystems.

<u>Monitoring and Continuing Research:</u> These two action items are combined since their effects would be the same. Monitoring includes visual surveys of restoration sites to determine if MYLFs are present, and to determine if fish are present. Research can include monitoring activities, or it can include active manipulation and experimentation with existing and new technologies and methods. Both monitoring and research could occur throughout the wilderness, at any time during the summer months. The duration depends on the types of activities, active monitoring and research could occur for a period of several days to several months. The overall monitoring and research program would occur for the foreseeable future.

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, resulting in a long-term trammel to wilderness.

Effects of Monitoring and Continuing Research on Natural: Research would have a short-term minor to moderate 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 management to prevent the MYLF from going extinct, and 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 minor to moderate 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 pens for a period of time (6 to 10 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. The effects on undeveloped would be adverse minor to moderate and short-term at specific project locations, but these effects would occur periodically for the life of the project (20 to 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 two to three people per project. As stated under “Effects of 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 occurs 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 minor to moderate 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.

<u>Fish Disposal:</u> Dead fish would have their swim bladders punctured and carcasses would be sunk to the substrate in deep waters. Given the oligotrophic (nutrient lacking) conditions, cool water temperatures, and seasonal flow variability in the high elevation aquatic ecosystems, any long-term eutrophication is expected to be very unlikely.

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) of a non-natural condition. Therefore there would be no effect on untrammeled as a result of the disposal of fish.

Effects of Fish Disposal on Natural: 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, but no long-term effects would occur. There would be short-term adverse impacts to water quality; the nutrients would ultimately be cycled back into the ecosystem where they originated resulting in a long-term beneficial effect. This would result in moderate short-term adverse effect to the natural quality of wilderness character.

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 sunk into the waters, resulting in no effect on solitude or primitive and unconfined recreation.

Cumulative Effects from Elements Common to All Action Alternatives - Wilderness

There are a wide variety of administrative activities (i.e. maintenance, resources management and research, and ranger activities) occurring within and adjacent to the parks’ wilderness at any given time.

There are generally 60 to 90 research permits issued per year for research within SEKI; approximately two-thirds of the research activities occur partly or wholly in the wilderness. At any given time there may be resources management activities occurring in or adjacent to the wilderness, such as invasive nonnative plants removal, disturbed lands restoration projects, and air quality and water quality/quantity monitoring. Some projects could occur in proximity to the proposed restoration sites.

The primary adverse effects of other resources management and science projects are from the installation of scientific equipment and use of mechanized / motorized equipment (e.g. helicopter and mechanized tools) on the undeveloped character; the trammeling that occurs during project work (e.g. pulling weeds and collaring wildlife); and use of mechanized / motorized equipment (e.g. helicopter and mechanized tools) and the presence of work crews which could affect solitude. Many of the projects result in long-term beneficial effects on the natural element of wilderness character from restoration, invasive species control, and increasing knowledge that helps managers make more informed decisions and better protect park resources.

There are also other project activities which result in the use of helicopters which affects the undeveloped quality and opportunities for solitude. Planned projects include annual mobilization and demobilization of ranger stations and facility maintenance projects (e.g. trails, bridge, and ranger station maintenance projects). Unplanned projects, including emergency actions (i.e. search and rescue and fire management) can also have an effect on the undeveloped and solitude qualities of wilderness character. Generally the planned projects do not overlap with the elements common to all alternatives, but they may. Regardless, these actions are cumulatively affecting the overall character of the wilderness. In addition, the presence of facilities determined to be necessary for the administration of the wilderness, such as ranger stations, adversely affects the undeveloped quality of wilderness, and recreational facilities, such as trails and bridges, adversely affects undeveloped and opportunities for solitude and primitive and unconfined recreation.

Overall, the incremental cumulative effect contributed by the elements common to all alternatives, while evident and observable, is still relatively small in proportion to the overall cumulative effect. In conclusion, there would be short- and long-term moderate adverse cumulative effects on undeveloped, short-term moderate adverse effects on the untrammeled quality, short-term minor to moderate adverse effects on solitude, short-term minor adverse effects for opportunities for primitive and unconfined recreation, and long-term beneficial cumulative effects on the natural quality of wilderness.

Conclusion: The overall effect on wilderness character from the presence of work crews camps and the use of helicopters and stock would be adverse minor to moderate and short- to long-term (up to 10 years per project site depending on the alternative selected). The effect from ecosystem restoration, monitoring and research would be minor to moderate, adverse and short- to long-term and beneficial effects on the natural quality of wilderness. There would be short- and long-term adverse effects on the untrammeled quality associated with any resource management or science activity that intentionally manipulates the natural system. There would be short-term beneficial and adverse effects on the natural quality from fish disposal activities.

Impacts of Alternative B: Prescription Treatment Preceding Restoration (Preferred Alternative) on Wilderness

Untrammeled: This alternative constitutes a long-term trammeling action on a landscape scale, considering the fish removals and restoration efforts would continue for the next 25 to 35 years in 55 basins. There would be site specific trammeling actions at up to six treatment sites per year, for several weeks each summer. Each site would require 1 to 7 years of treatment, with some sites treated for up to 10 years. The trammeling actions include the physical and piscicide treatments to remove nonnative fish, which are an intentional manipulation of the wilderness. Over the life of the project (25 to 35 years), physical treatment would be used for 52 waterbodies (27 lakes, 24 ponds, 1 marsh; total of 492 ac/199 ha) and approximately 15 mi (25 km) of streams in 17 basins; piscicide treatment would be used for 33 waterbodies (4 lakes, 25 ponds, 4 marshes; total of 142 ac/57 ha) and approximately 16 mi (25 km) of streams in 9 basins (Table 9, Table 10 and Table 11; and Figure 7). 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 most sites, or 1 to 3 years at one or more of the largest sites. Active work by crews would occur primarily during the summer (up to 10 days per site visit up to 7 times a season). Passive winter netting (i.e. leaving the nets in the waters 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 3 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 “Special-status Species” and “Wildlife” sections.

Natural: Under this alternative, there would be approximately 465 waterbodies plus connecting streams containing self-sustaining nonnative trout populations, which is a long-term adverse effect on the natural quality of wilderness. The 85 waterbodies proposed for fish removal and restored to natural conditions under this alternative represent 15% of the parks’ 550 waterbodies known to contain nonnative fish.

Aquatic ecosystem restoration would occur over the next 25 to 35 years in 55 basins, including the eradication of nonnative fish in 21 basins (80 lakes and ponds, 5 fish-containing marshes, approximately 31 mi (50 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 amphibian chytrid fungus and other stressors (e.g., climate change, air pollution) can be mitigated. There would be adverse effects on the natural quality of wilderness during piscicide treatments (see “Special-status Species” and “Wildlife” sections). Because piscicides are non-selective (they kill most gill breathing organisms), there would be a short-term moderate to major adverse effect on the natural quality of wilderness at the piscicide treated areas, 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).

Undeveloped: Under this alternative, the undeveloped quality of wilderness would be affected by the equipment that would be used for the project work, including gill nets and fish traps used for physical treatment, and small electric pumps used for piscicide treatment, the presence of crew camps, and the use of helicopters. The effects on the undeveloped quality of wilderness character from installations would be short term during project activities, and long-term where 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. Generally lockers would not be needed at the piscicide sites because the project duration is 1 to 2 weeks. Project work would occur in selected areas of the wilderness over the life of the project. All of the installations would be removed after project work is completed at each site. No permanent improvement or modern human occupation would occur at any of the restoration sites.

There could be up to three helicopter flights/landings 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 in 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 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 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 at most treatment sites, and potentially 16 to 25 people at one or more of the largest treatment sites. 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 a few 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 minor adverse effect on opportunities for solitude.

There would be a reduction in opportunities for primitive recreation (e.g. angling) resulting from reduced angling opportunities at 85 of the parks' waterbodies and 31 mi (50 km) of streams. There would continue to be angling opportunities at 465 waterbodies. 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 7 to 14 days per treatment, resulting in negligible to minor adverse effects on opportunities for unconfined recreation.

The use of helicopters would reduce opportunities for solitude as it would affect the natural soundscape on a short-term basis, affecting opportunities for solitude on the flight path and at the project sites. 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.

Cumulative Effects – Alternative B - Wilderness

As stated under alternative A, there are numerous past, present, and reasonably foreseeable future actions that affect wilderness character. There are adverse effects associated with the past stocking of nonnative trout, administrative and research-related activities resulting in short-term trammeling activities, short and long-term developments, and reduced opportunities for solitude. There are long-term beneficial effects on wilderness character by restoring the natural quality of wilderness by managing and controlling invasive nonnative plant species, maintaining a trail system to reduce resource impacts, and restoring native species to their historical ranges.

While most of these projects do not overlap with the proposed restoration sites, when considering the wilderness as a whole, and when considered with past, present, and future potential activities, alternative B would add to the existing adverse effects on the untrammeled and undeveloped elements of wilderness character, and would reduce opportunities for solitude in up to six restoration sites a year, in various locations within the wilderness, for the next 25 to 35 years. This would result in short- and long-term moderate adverse cumulative effects when considering the wilderness as a whole. This alternative would improve the natural quality of wilderness in the long term, and when combined with other project work that would accomplish the same goal, would result in long-term beneficial cumulative effects to the natural quality of wilderness.

Conclusion: Over the life of the project (25 to 35 years), aquatic ecosystem restoration would occur in 55 basins, including the eradication of nonnative fish in 21 basins (80 lakes and ponds, 5 marshes, approximately 31 mi (50 km) of streams, plus connected fish-containing habitat as necessary). Under this alternative, trammeling would occur at restoration sites as a result of project work, including the use of gill nets, electrofishers, and piscicide application. The effects at individual restoration sites would be short-term, moderate and adverse, but on a landscape scale, there would be long-term adverse effects on untrammeled until project work is completed. The presence of self-sustaining nonnative trout populations in approximately 465 waterbodies plus connecting streams contained in 69 basins would result in a long-term major adverse effect on the natural quality of wilderness.

There would be short- to long-term adverse effects on the undeveloped quality from the installation of gill nets, equipment/food storage lockers, and the use of helicopters. There would be an adverse effect on solitude from the presence of crews and the use of helicopters and an adverse effect on angling opportunities.

There would be a long-term benefit from restoring the natural quality of wilderness in 15% of the approximately 550 waterbodies that are known to contain self-sustaining nonnative fish populations. There would be short-term adverse effects on the natural quality of wilderness from the use of piscicides. The tools needed to accomplish the restoration create short-term adverse effects on the undeveloped quality of wilderness. The presence of work crews may slightly affect opportunities for solitude in active restoration areas. Area closures would slightly reduce opportunities for primitive and unconfined recreation.

Impacts of Alternative C: Physical Treatment Preceding Restoration on Wilderness

Untrammeled: The trammeling activities associated with alternative C include removing nonnative fish by physical methods (gill netting, electrofishing, fish traps, redd disruption and/or covering) and blasting a permanent physical barrier in up to five streams – all of which are intentional manipulations of the wilderness. There would be no use of piscicides in 33 waterbodies and approximately 16 mi (25 km) of stream, resulting in fewer treated sites and fewer trammeling actions that alternatives B and D. Over the 25 to 35 year project, physical treatment would be used for 52 waterbodies (27 lakes, 24 ponds, 1 marsh; total of 492 ac/199 ha) and approximately 15 mi (25 km) of streams contained in 17 basins. The trammeling actions include use of gill nets and electrofishers which are an intentional manipulation of the wilderness resulting in the removal nonnative fish. Up to five sites would be treated each year for the life of the project. 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 and trammel of the stream.

Natural: Under this alternative, there would continue to be 498 waterbodies containing self-sustaining nonnative trout populations, which results in a long-term adverse effect on the natural quality of wilderness (see “Wildlife” and “Special-status Species” sections). Aquatic ecosystem restoration would occur over the next 25 to 35 years in up to 55 basins; physical treatment would be used for 52 waterbodies (27 lakes, 24 ponds, 1 marsh; total of 492 ac/199 ha) and approximately 15 mi (25 km) of streams contained in 17 basins. In comparison to alternative B, excluded from the list of proposed restoration 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.

The 52 waterbodies that would be treated under this alternative represent 9% of the parks’ approximately 550 waters known to contain self-sustaining nonnative trout populations. These 55 basins would be restored to a more natural condition under this alternative.

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 installation of gill nets, the presence of crew camps and storage lockers, blasting of stream barriers in up to five locations, and the use of helicopters during project work. The effects on the undeveloped quality of wilderness character from gill net installations would be short term during project activities, and long-term where gill nets are deployed over the winter months. 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. None of this development would be permanent, and no permanent improvement or modern human occupation would occur at any of the restoration sites.

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 B, 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 B. 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 in 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 be one to five crew camps in wilderness each year. The crews implementing physical treatment would involve two to three workers per site, occupying the 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 minor adverse effects on opportunities for primitive recreation (e.g. angling) resulting from reduced angling opportunities at 52 of the parks' waterbodies and 15 mi (25 km) of streams. There would continue to be 498 waterbodies providing opportunities for anglers. 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.

The use of helicopters would reduce opportunities for solitude as it would affect the natural soundscape on a short-term basis, affecting opportunities for solitude on the flight path and at the project sites. 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.

Cumulative Effects – Alternative C - Wilderness

As discussed under alternative A, there are numerous past, present, and future foreseeable actions that affect wilderness character. While most of these projects do not overlap with the proposed restoration sites, when considering the wilderness as a whole, and when considered with past, present, and future potential activities, alternative C would add to the existing adverse effects on the untrammeled and undeveloped elements of wilderness character, and would reduce opportunities for solitude in up to three restoration sites a year, in various locations within the wilderness, for the next 25 to 35 years. This would result in short- and long-term moderate adverse cumulative effects when considering the wilderness as a whole. This alternative would improve the natural element of wilderness in the long term, and when combined with other project work that would accomplish the same goal, would result in long-term beneficial cumulative effects to the natural element of wilderness.

Conclusion: Over the 25 to 35 year life of the project, there would be 52 waterbodies and approximately 15 mi (25 km) of streams contained in 17 basins treated by physical methods (e.g., gill netting and electrofishing). Under this alternative, trammeling would occur at restoration sites as a result of project work, including the use of gill nets, electrofishing, and blasting (if determined necessary). These effects at individual restoration sites would be short-term, moderate and adverse, but on a landscape scale, there would be long-term adverse effects on untrammeled until project work is completed. Blasting would result in a long-term minor to moderate adverse effect on the natural quality of wilderness and a long-term minor adverse effect on the undeveloped quality.

There would be a short to long-term adverse effect on the undeveloped quality from the installation of gill nets, equipment/food storage lockers, and the use of helicopters. There would be an adverse effect on solitude from the presence of crews and the use of helicopters and an adverse effect from reduced angling opportunities.

There would be a long-term benefit of restoring the natural quality of wilderness in 9% of the approximately 550 waterbodies that are known to contain nonnative fish populations. However, 498 waterbodies would still contain self-sustaining fish populations. Therefore the beneficial effects from this alternative are less than alternatives B and D.

Impacts of Alternative D: Piscicide Treatment Preceding Restoration on Wilderness

Untrammeled: This alternative constitutes a long-term trammeling action on a landscape scale, however the trammeling would be reduced to 15 to 20 years, as opposed to alternatives B and C where trammeling would occur for the next 25 to 35 years. Under this alternative, there would be short-term adverse effects at each project site as a result of trammeling due to the use of piscicides to eradicate nonnative fish from 80 lakes and ponds (602 ac/244 ha), 5 associated fish-containing marshes (32 ac/13 ha), approximately 31 mi (50 km) of streams, plus connected fish-containing habitat as necessary. 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 (measuring habitat and collecting samples in the summers before and after each treatment). Treatment sites would be occupied for 2 to 4 weeks each year; assessment sites would be occupied for 1 to 2 weeks each year. 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, thus the long-term trammeling actions would be completed sooner than in alternatives B and D.

Natural: Under this alternative, there would be 465 waterbodies that would continue to support 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 21 basins, including 80 lakes and ponds (602 ac/244 ha), 5 associated fish-containing marshes (32 ac/13 ha), approximately 31 mi (50 km) of streams, plus connected fish-containing habitat as necessary. Nonnative fish would be removed from 15% of the parks' 550 waterbodies known to contain nonnative fish. There would be a temporary adverse effect on the natural quality of wilderness from the use of piscicides (see "Wildlife" and "Special-status Species" sections). 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 undeveloped quality of wilderness would be affected by the piscicide treatment (which utilizes a small electric pump), the crew camps, and the use of helicopters. The use of a small electric pump associated with piscicide use creates a short-term adverse effect on the undeveloped quality of wilderness. There would be up to six temporary crew camps in wilderness per year, including up to two conducting treatment activities and up to four conducting pre- or post-treatment assessment activities. Treatment sites would be occupied for 2 to 4 weeks in the summer for up to 3 years per site; assessment sites would be occupied for 1 to 2 weeks in the summer for up to 4 years per site. Because the sites would be occupied for up to 4 weeks, food and equipment storage lockers would not be necessary. None of the development would be permanent, and no permanent improvement or modern human occupation would occur at any of the restoration sites.

Helicopter use would be similar to alternative B. There would be up to three restoration projects per summer, with two projects occurring simultaneously. 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 in 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: 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 4 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 at most sites and potentially 16 to 25 people at one or more the largest treatment sites; 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 reduced opportunities for primitive recreation (e.g. angling) resulting from removing nonnative fish, thus removing angling opportunities at 85 of the parks' waterbodies and 31 mi (50 km) of streams. There would continue to be angling opportunities at 465 waterbodies. 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.

The use of helicopters would reduce opportunities for solitude as it would affect the natural soundscape on a short-term basis, affecting opportunities for solitude on the flight path and at the project sites. 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 on opportunities for unconfined recreation would be negligible and short-term.

Cumulative Effects – Alternative D - Wilderness

The cumulative impacts are similar to those described under alternative B, except that piscicides would be used at more sites with each site requiring a shorter period of time per site for treatment activities (1 to 2 years at most sites, or 1 to 3 years at one or more of the larger sites, over the 15 to 20 years to fully implement this alternative), resulting in greater trammeling actions in the short-term than alternatives B and C. The natural quality of wilderness would be temporarily altered due to the use of piscicides, but would be restored at faster rate. Therefore, when considering the wilderness as a whole, and when considered with past, present, and future potential activities, alternative D would result moderate to major short-term adverse cumulative effects on wilderness character, and long-term beneficial effects.

Conclusion: Over the life of the project (15 to 20 years), there would be 82 lakes and ponds, 5 associated marshes, approximately 31 mi (50 km) of streams, and connected fish-containing habitat (as necessary) treated by the use of piscicides. Trammeling would occur on a landscape scale for 15 to 20 years and at each site for the duration of the piscicide treatment; up to 20 days per site per season over a 1 to 3 year period. 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.

The use of piscicides would have a short-term moderate to major adverse effect on the natural quality of wilderness. However, in the long term, natural conditions would be restored to 15% of the 550 waterbodies known to contain nonnative fish populations.

There would be a short to long-term adverse effect on the undeveloped quality from the use of an electric pump (associated with piscicide use), and the use of helicopters. There would be an adverse effect on solitude from the presence of crews and the use of helicopters and an adverse effect from reduced angling opportunities.

NATURAL SOUNDSCAPES

Methodology for Analyzing Impacts

NPS *Management Policies* 2006 (NPS 2006A), state that "the National Park Service will preserve, to the greatest extent possible, the natural soundscapes of parks." The policies require the restoration of degraded soundscapes to the natural condition whenever possible, and the protection of natural soundscapes from degradation due to human-caused sounds. The NPS is specifically directed to "take action to prevent or minimize all noise that, through frequency, magnitude, or duration, adversely affects the natural soundscape or other park resources or values, or that exceeds levels that have been identified as being acceptable to, or appropriate for, visitor uses at the sites being monitored." Overriding all of this is the fundamental purpose of the national park system, established in law (e.g., 16 U.S.C. 1 et seq.), which is to conserve park resources and values. NPS managers must always seek ways to avoid, or to minimize to the greatest degree practicable, adverse impacts on park resources and values.

Noise can adversely affect the parks' resources by modifying or intruding upon the natural soundscape, and can also interfere with sounds important for animal communication, navigation, mating, nurturing, predation, and foraging functions. Noise can also adversely affect park visitor experiences by intruding upon or disrupting experiences of solitude, serenity, tranquility, contemplation, or a completely natural or historical environment. The methodology used to assess noise impacts in this document is consistent with NPS *Management Policies* 2006 (NPS 2006A) and *Director's Order 47: Soundscape Preservation and Noise Management* (NPS 2000).

Context, time, and intensity together determine the level of impact for an activity. It is usually necessary to evaluate all three factors together to determine the level of noise impact. In some cases an analysis of one or more factors may indicate one impact level, while an analysis of another factor may indicate a different impact level, according to the criteria below (Table 28). In such cases, best professional judgment based on a documented rationale must be used to determine which impact level best applies to the situation being evaluated.

Table 28. Soundscape Impact and Intensity Descriptions

Impact Intensity	Intensity Description
Negligible	Natural sounds would prevail. Effects on the natural sound environment would be at or below the level of detection and such changes would be so slight that they would not be of any measurable or perceptible consequence to the visitor experience or to biological resources.
Minor	Natural sounds would prevail. Effects on natural sound would be localized and short-term and would be small and of little consequence to the visitor experience or to biological resources. Mitigation measures, if needed to offset adverse effects, would be simple and successful.
Moderate	Natural sounds would prevail, but activity noise could occasionally be present at low to moderate levels. Effects on the natural sound environment would be readily detectable, localized, and short-term or long-term, with consequences at the regional or population level. Human-generated noise would be occasionally heard during the day. Mitigation measures, if needed to offset adverse effects, would be extensive and likely successful.
Major	Natural sounds would be impacted by activity noise frequently for extended periods of time. Effects on the natural sound environment would be obvious and long-term, and would have substantial consequences to the visitor experience or to biological resources in the region. Extensive mitigation measures would be needed to offset any adverse effects and success would not be guaranteed.

Short-term—effects would only be evident during project work.

Long-term—effects would occur after project work ends.

Impacts of Alternative A: No Action on the Natural Soundscape

Under this alternative, restoration crews would generate noise from speaking to each other in close proximity to project sites, resulting in short-term negligible adverse effects on the natural soundscape in the project areas.

Under this alternative, nonnative fish removal would be completed in 25 previously approved waterbodies (15 complete, 10 nearly completed), restoring the natural soundscape at these locations. At the 550 locations where nonnative fish have eliminated or reduced the number of native species and no restoration actions are proposed, there would continue to be missing elements of the natural soundscape. Elements such as frog vocalization, the audible trill of the Yosemite toad, and the calls of the grey-crowned Rosy Finches, are not as numerous in areas with nonnative fish populations. The sounds of Clark's Nutcrackers, Brewer's Blackbirds, and other wildlife that feed on frogs or the insect hatch from lakes would be expected to be reduced at the sites with populations of nonnative fish. Some sounds beyond our hearing range would be lost. The nighttime echolocations of bats are probably richer at fishless sites, at least during insect hatches. Most wilderness users probably would not notice the differences in sounds at lakes with and without introduced fish, but the differences are real and long-term. Because the loss of certain natural sounds would be long-term and even permanent in some areas, the impact would be adverse and major where nonnative fish continue to occupy waterbodies. At the 25 treated sites, the impact would be beneficial.

Cumulative Effects – Alternative A – Natural Soundscape

The additive sounds of project crews would be negligible and localized and would not contribute to the overall loss of natural sounds within the parks' wilderness. However, there could be nearby projects which could adversely affect the natural soundscape. For example, if there is a nearby trail project, there could be noise associated with the presence of crews and the use of mechanized equipment (chainsaws, rock drills, and helicopters on occasion). There generally would be very little overlap between timing and location of maintenance actions and aquatic ecosystem restoration activities, but there could be some. Visitors could experience noise from trail projects and restoration projects in a single wilderness visit or even in a single day. However, the incremental effect contributed by the alternative, while evident and observable, is still relatively small in proportion to the overall cumulative impact. The cumulative effects would be short-term minor and adverse.

The loss of natural sounds within the Sierra Nevada range from the continued reduction in native species would be expected to continue even with ongoing restoration projects range wide. This stems primarily from the loss of frog vocalizations and birds in areas where ecosystem integrity has been lost due to the presence of nonnative fish. While some areas would be restored under this alternative, many other areas would not be restored and would lose components of the natural soundscape, resulting in moderate to major adverse cumulative effects in the Sierra Nevada where restoration is not occurring, and long-term beneficial effects where aquatic ecosystem restoration is achieved.

Conclusion: This alternative results in negligible short-term adverse effect from unnatural sounds caused by project crews talking. This alternative would result in continuous loss of the components of the natural soundscape over much of the high elevation landscape, including frog vocalization in many areas of the parks, which would result in a major adverse long-term effect. Cumulative effects when considering this alternative with other actions ongoing wilderness wide and in adjacent lands would be short- to long-term minor and adverse in terms of the presence of work crews; long-term adverse and moderate to major from the loss of components of the natural soundscape; and long-term and beneficial from restoring components of the natural soundscape on a limited basis.

Impacts from Elements Common to All Action Alternatives on the Natural Soundscape

The following is the analyses of those elements common to all alternatives that could have an effect on the natural soundscapes of the parks.

<u>Crew Camps:</u> Crew camps would be selected away from popular visitor use corridors, and away from the more popular and highly used visitor campsites. There is a potential that a crew camp would be located where a visitor could hear crew members in the camp. The camps would be smaller for the proposed physical treatment sites (2 to 3 people) and larger for the proposed piscicide treatment sites (8 to 15 people at most sites; potentially 16 to 25 people at one or more of the largest sites). The presence of these campsites, though temporary in nature, may adversely affect the visitor experience for those who hear noise generated from the camp areas, but this noise would primarily be crew members talking.

Conclusion: Effects of crew camps would be short-term, temporary and localized, resulting in short-term negligible adverse effects on the natural soundscapes.

<u>Use of Helicopters and Stock:</u> The use of helicopters and stock may also adversely affect the natural soundscapes. Two helicopter flights would occur per project site; one at the beginning of a project to transport supplies that could not be transported by stock or humans, and one at the end of a project to transport supplies out of the wilderness. Flight paths vary depending on where the project is located, but could originate from either the Ash Mountain or Cedar Grove helibase.

The parks use a Type 3 (or III) "Light" helicopter for almost all of the missions. The current helicopter under contract with the NPS is a Type 3 Eurocopter AS350 B-3. It is expected in the future that a similar helicopter would be available for use for special missions within SEKI including the transport of supplies, where necessary, for the proposed high elevation restoration project. Studies have shown that light helicopters such as the AS350 B-3 generate the following noise: Takeoff: 89.7; Overflight: 87.3; Approach 91.3 (EPNdB) (TAR April 2012).

Many visitors do not like to hear helicopters when they are in the wilderness. The noise from helicopters alters the natural soundscape of the wilderness during the period that helicopters are present.

The use of stock may adversely affect the natural soundscapes, from the sound of horses and mules. Stock camps are more of a noise concern because of the common practice of attaching bells to some of the stock to keep track of them while grazing. Some visitors consider this a historic and accepted use of the wilderness and enjoy hearing stock groups. Others do not like the noise associated with recreational and administrative stock use. Regardless, the presence of stock introduces an unnatural element on the natural soundscape.

Conclusion: The use of helicopters results in short-term moderate adverse effects on natural soundscapes within the project areas, and within and around transportation corridors (whether flight lines or trails) to the project areas, and the use of stock results in short-term minor adverse effects on natural soundscapes.

<u>Restoration of Mountain Yellow-Legged Frogs, Monitoring, Continuing Research, and Fish Disposal:</u> These elements are combined as they have similar effects to natural soundscapes. All of these elements require the presence of work crews and could include the use of equipment and the placement of temporary scientific measuring devices. Most of the work would not generate noise above a normal speaking voice, resulting in short- to long-term negligible adverse effects on the natural soundscape in localized areas.

Conclusion: Restoration activities, monitoring, research, and fish disposal would result in short- to long-term negligible adverse effects on the natural soundscape in localized areas.

Cumulative Effects from Elements Common to All Action Alternatives – Natural Soundscape

Natural soundscapes within SEKI are affected by human activities. Within the wilderness, the primary noise-producing activities are the use of helicopter and aircraft.

From May through October the parks have a helicopter based at the park headquarters at Ash Mountain for use in fire management activities, search and rescue operations (SARs), and support of wilderness administration activities. Except for SARs, most helicopter operations are completed in less than 30 minutes at the operation site. The helicopter normally based at SEKI is classified as a light helicopter (Type 3). There is an average of 257 hours of planned and unplanned hours of helicopter flight time per year within and outside wilderness (NPS Files).

Other park operations that produce human-generated noise in the wilderness include trail maintenance activities, where mechanized and non-mechanized tools may be used depending on the circumstances. Occasionally the trail crew uses blasting to create and maintain trails. The noise of crews working and talking can adversely impact the natural soundscape.

Outside sources of noise include military and commercial overflights, which occur periodically over the parks. Rangers are responsible for reporting violations of military aircraft flying below 3,000 ft (900 m) above ground level over the wilderness areas of the park. The parks work closely with command staff at

Edwards Air Force Base to reduce and eliminate such violations of military regulations. The noise created by these low-level flights can be especially intrusive on the natural soundscapes.

Taken together, all of these activities create minor to moderate temporary and relatively localized adverse effects on the natural soundscape.

The sounds from crews, pack stock, and helicopters proposed under "Impacts from Elements Common to All Action Alternatives" would be in addition to the other human-generated sounds that may occur throughout these parks. It is difficult to measure the cumulative effects since unnatural sounds can be generated at localized areas at any given time, depending on the project location, parks operation, and non-park related activities (e.g. commercial and military overflights). However, most noise-generated activities that occur within the parks are temporary localized, and do not permanently alter the natural soundscape.

When considering the infrequent flights that would occur as a result of these alternatives (maximum two per year per location), the infrequent use of stock (maximum two trips per year per location), and the minimal sound of small work crews (two to five people at each project site), the project activities associated with "Elements Common to All Action Alternatives" would add slightly to the existing and ongoing adverse effects to the natural soundscape. Therefore the cumulative effects on the natural soundscape would be minor to moderate short-term and adverse.

Impacts of Alternative B: Prescription Treatment Preceding Restoration (Preferred Alternative) on the Natural Soundscape

Noise associated with project work would be the same as described under alternative A, except in some areas, work crews would be larger (8 to 15 people at most piscicide treatment sites; potentially 16 to 25 at one or more of the largest piscicide treatment sites) so they would generate more noise. Noise levels from human voices in a localized area would be temporary and create negligible adverse effects on the natural soundscape around the project sites.

Under this alternative, nonnative fish would be removed from 85 waterbodies and 31 mi (50 km) of streams in 21 basins, restoring the natural soundscape at these locations. At the 465 waterbodies plus connecting streams (contained in 69 basins) where nonnative fish have eliminated or reduced the number of native species and no restoration actions are proposed, there would continue to be missing elements of the natural soundscape. As restoration is completed at each site, components of the natural soundscape would be restored. As the work is completed, this alternative would provide for a long-term benefit to natural soundscapes. If fully successful, the sounds of frogs, insects, birds and mammals within the restoration sites would come closest to the pristine sounds that are heard in a natural environment.

Cumulative Effects – Alternative B – Natural Soundscape

As described under alternative A, the additive sounds of project crews would be negligible and localized and would not contribute to the overall loss of natural sounds within the parks' wilderness. Since the project components are expanded, however, there would be an increased chance for the parks' visitors to experience noise from a variety of administrative actions in one day and/or in one area. However, the incremental effect contributed by the alternative, while evident and observable, is still relatively small in proportion to the overall cumulative impact. The cumulative effects would therefore be negligible short-term and adverse.

The restoration of natural sounds within the project area would result in beneficial cumulative effects to the Sierra Nevada ecosystem as described under alternative A. Since this alternative would result in additional sites restored, if restoration is successful, more of the natural soundscape range wide would be restored over the life of this project as compared with alternative A.

Conclusion: Sounds made by crews are expected to have a short-term negligible adverse effect on natural soundscapes in a localized area. The impacts would last until the restoration is completed for each site. As each restoration site is completed, natural sounds would be restored as native species return to the sites. This would improve the natural soundscapes in the restoration areas.

Impacts of Alternative C: Physical Treatment Preceding Restoration on the Natural Soundscape

Noise associated with project work would be the same as for alternative B except that the duration of impacts would be slightly shorter for the project area since fewer sites are involved, and slightly reduced from the smaller crew sizes (two to three people per project site). In addition, blasting rock to create vertical fish barriers in physical treatment areas would be conducted (if determined necessary) in up to five locations. Loud noise from blasting would be temporary and create a minor to moderate short-term adverse effect on the natural soundscape around those project sites.

Under this alternative, nonnative fish would be removed from 52 waterbodies and 15 mi (25 km) of streams in 17 basins, restoring the natural soundscape at these locations. At the 498 waterbodies plus connecting streams (contained in 80 basins) where nonnative fish have eliminated or reduced the number of native species and no restoration actions are proposed, there would continue to be missing elements of the natural soundscape.

Cumulative Effects – Alternative C – Natural Soundscape

The cumulative effects from alternative C would include the same effects as described for alternative B. In addition, loud noise from blasting in up to five locations would create a short-term minor to moderate adverse effect on the natural soundscape around those project sites.

Conclusion: Sounds made by crews would have a short-term negligible adverse effect on natural soundscapes in a localized area. The impacts would be short-term lasting only until the restoration is completed for each site. Loud noise from blasting would have a short-term minor to moderate adverse effect on natural soundscapes around those project sites. As each restoration site is completed, natural sounds would be restored as native species return to the sites. This would improve the natural soundscapes in the restoration areas.

Impacts of Alternative D: Piscicide Treatment Preceding Restoration on the Natural Soundscape

Impacts from alternative D to the natural soundscape would be the same as identified for alternative B, except that because piscicide treatments are more efficient than physical treatments, the period of impacts would be reduced as compared with alternatives B and C. Under this alternative, nonnative fish would be removed from 85 waterbodies and 31 mi (50 km) of streams in 21 basins, restoring the natural soundscape at these locations. At the 465 waterbodies plus connecting streams (contained in 69 basins) where nonnative fish have eliminated or reduced the number of native species and no restoration actions are proposed, there would continue to be missing elements of the natural soundscape. Because of the larger crews, this alternative might have slightly more impact on natural soundscapes than alternative B, but for a shorter period of time. Noise levels from human voices in a localized area would be temporary and create negligible adverse effects on the natural soundscape around the project sites.

Cumulative Effects – Alternative D – Natural Soundscape

The cumulative effects from alternative D would be the same as described for alternative B.

Conclusion: Sounds made by crews would have a short-term negligible adverse effect on natural soundscapes in a localized area. The impacts would be short-term lasting only until the restoration is completed for each site and would only occur during the summer field season (late-June or early-July through September). As each restoration site is completed, natural sounds would be restored as native species return to the sites. Their return would improve the natural soundscapes in the restoration areas. Cumulative effects from the potential for overlapping projects are short term minor and adverse. There would also be beneficial effects from restoring the natural soundscapes in a larger portion of the parks' wilderness, resulting in beneficial effects on natural soundscapes in the Sierra Nevada.

HEALTH AND SAFETY

Methodology for Analyzing Impacts

NPS *Management Policies* 2006 (NPS 2006A) state that although there are limitations on the NPS ability to totally eliminate all hazards, the NPS will strive to provide a safe and healthful environment for visitors and employees, to protect human life and to provide for injury-free visits. Safety, for the purposes of this analysis, refers to the potential for each alternative to directly or indirectly inflict injury on the parks visitors or employees, and park neighbors, including:

Risks associated with working and living in high elevation wilderness areas;

The potential effects from the use of gill nets and electrofishers on park employees and visitors;

The effect on human health from the potential toxicological impacts on people from the proposed use of commercial rotenone liquid formulations. Application of rotenone and potassium permanganate to the environment could result in toxic effects (Appendices G and H);

The risks associated with the use of helicopters for transport of materials and equipment. Mitigation measures and compliance with required policies serve to reduce these risks; however, they can never be completely eliminated. Therefore, there is the potential for injury and loss of human life during these operations (Table 29).

Table 29. Health and Safety Impact and Intensity Descriptions

Impact Intensity	Impact Description
Negligible	The impacts on health and safety would not be measurable or perceptible.
Low Risk	The effect on human health and safety would be detectable but short-term, would be limited to a relatively small number of parks staff at a localized area, and would not have an appreciable effect on public health and safety.
Moderate Risk	The effects would be sufficient to cause a permanent change in forecasting accuracy or would be readily apparent and would result in substantial, noticeable effects on safety on a local scale on a short- or long-term basis.
Major Risk	The impact on human health and safety would be substantial. Effects would be readily apparent and would result in substantial, noticeable effects on safety on a regional scale and on a long-term basis.

Short-term—effects last during project work.

Long-term—effects last beyond the end of the project work.

Impacts of Alternative A: No Action on Health and Safety

Visitor health and safety: The threat to the wilderness user from alternative A is the potential to become entangled within a gill net when swimming. The threat of entanglement is low, even if a swimmer made contact with a net. The net mesh has a maximum diameter of 1.5 inches (38 mm) designed to entangle fish, not people. Additionally, the threat is mitigated in three ways: (1) the natural approaches to lakes are posted with temporary notices to warn a potential swimmer of the threat; (2) nets are set deep to be under most swimmers' feet; (3) if nets are needed in shallow water for certain fish, they are set so shallow to not be a risk to people; (4) most treatment sites are visited infrequently by the public and nets are set at areas least likely to be used by swimmers; and (5) crews are present most of the time when water is warm enough for swimming. The risk to human safety is negligible to low.

Employee health and safety: Threats to employee safety include working in deep and very cold water, handling nets that can become entangled on clothing, walking on slippery wet surfaces, cross-country travel, working at high elevations, and working in water using high voltage electrofishers to stun fish.

Employees are trained in safety and job hazard analyses which are conducted for each component of the job, reducing the risks. Threats are managed and risks are lowered by proper training, insisting on consistent use of proper equipment and protocols, priority emphasis on group and personal safety, and hiring people who are experienced at sustained living at high elevations and physically fit to do the work safely. However, no operation can be risk free. Since 2001, ecosystem restoration activities have resulted in two injuries to park staff – one sprain and one strain. The low likelihood of injury is not expected to change under this alternative; the chance of injury from project work would be eliminated in 2017 after project work is completed.

Cumulative Effects – Alternative A – Health and Safety

There are inherent risks to visitors and employees who visit or work in wilderness. Per NPS *Management Policies 2006*, the parks' visitors need to accept wilderness on its own unique terms. Accordingly, the NPS will promote education programs that encourage wilderness users to understand and be aware of certain risks, including possible dangers arising from wildlife, weather conditions, physical features, and other natural phenomena that are inherent in the various conditions that comprise a wilderness experience and primitive methods of travel. The NPS will not modify the wilderness area to eliminate risks that are normally associated with wilderness, but it will strive to provide users with general information concerning possible risks, any recommended precautions, related user responsibilities, and applicable restrictions and regulations (Section 6.4.1).

Each year visitors are injured and there are search and rescues in wilderness. This alternative would not add to the inherent risk associated with wilderness recreation. Employees who work in wilderness are trained on the hazards of wilderness work. This alternative would not add to the risks associated with employees' working in wilderness. There would be no cumulative effects to public and employee safety.

Conclusion: This alternative would result in no appreciable effect on public health and safety. Employee risks are mitigated, but employees still assume personal responsibility for their safety, whether on or off duty. There still could be risks to employee safety until the ongoing project work is completed, but the risks are low to moderate.

Impacts from Elements Common to All Action Alternatives on Health and Safety

The following is the analyses of those elements common to all alternatives that could have an effect on human health and safety.

Crew Camps: The ongoing restoration program occurs in the wilderness of SEKI; most crew camps are located away from the primary trail corridors. Living within the wilderness and at high elevations has risks. Each year parks managers and crews prepare job hazard analyses and review these with a goal of reducing exposure to risks. Safety training occurs prior to each field season, and includes education about living in the wilderness, and working around helicopters and stock. There still is the potential for accidents, however, the likelihood of an accident is low based on 14 years of field experience. These project components would not affect public health and safety.

Use of Helicopter and Stock: Helicopter use is inherently dangerous. The flights in all alternatives would be limited to those necessary for the transport of materials that are unable to be transported by stock or carried in by crews. Except for emergencies, flights would be limited to one round trip at the initiation of project work, and one round trip at the completion of project work for each project location. An experienced crew is utilized to manage park helicopter operations. However, there is still the potential for accident and injury from helicopter use. Use of an experienced crew and helicopter pilot and adherence to safety requirements reduces the potential for accidents. The likelihood of an accident is low based on many years of experience.

Stock use has the potential to create hazards. Stock crews are highly trained and experienced working in the SEKI wilderness. However, there is still the potential for employee or visitor injury from stock use. Use of an experienced wrangler and adherence to job hazard analyses reduces the potential for accidents. The likelihood of an accident is low based on 14 years of field experience. These project components would not affect public health and safety.

Restoration of Mountain Yellow-Legged Frogs, Monitoring, Continuing Research, and Fish Disposal: These project components would not affect public health and safety. Work that occurs in remote and isolated wilderness has risks. Crews working in the wilderness have the potential for accidents and injuries. This risk is mitigated through the implementation of standard practices, conducting job hazard analyses, and training employees on proper procedures. The likelihood of an accident is low. These project components would not affect public health and safety.

Conclusion: While there are risks associated with the activities included in “Elements Common to All Alternatives” the likelihood of an accident is low if proper procedures are adhered to. There would be no effect on public health and safety.

Cumulative Effects from Elements Common to All Action Alternatives – Health and Safety

There are inherent risks associated with wilderness work. None of the elements in this alternative would add to the risks associated with employees’ working in wilderness. There would be no cumulative effects to public and employee safety.

Impacts of Alternative B: Prescription Treatment Preceding Restoration (Preferred Alternative) on Health and Safety

Visitor health and safety: The effects from gill netting would be the same as described under alternative A, however it would occur over a longer duration and at more sites

Under this alternative, rotenone formulations and the neutralizing agent (potassium permanganate) would be applied to selected treatment areas. Appendices G and H present detailed information on these agents and the potential effects to humans and biological resources. The following provides a summary of that information.

During piscicide treatments, there would be a threat to the wilderness visitor from the potential exposure to the piscicide. Prior to the rotenone application, and throughout the treatment process, the public would be notified through the use of signs located at trailheads, ranger stations, when obtaining wilderness permits, and other strategic places of the treatment process. In addition, field crews would search for visitors in the area and notify them of the treatment. Because many of the treatment sites are away from popular visitor use areas, these areas generally have little visitation. Thus, the only human receptors at risk would be the crew members applying the piscicide.

Public comments submitted during the scoping period expressed concerns about the potential effects of rotenone on human health. In the comprehensive assessments conducted as part of the rotenone re-registration process, the EPA (2007A) concluded that most risks from rotenone are below the EPA level of concern (LOC).

Under this alternative, the target concentration at which rotenone would be applied is about 42 µg/l, but may vary from 25 to 50 µg/l and could be as high as 100 µg/l in some situations. The estimated toxicity (as LD50) of rotenone to people is 136 to 227 mg/lb (300 to 500 mg/kg; Gosselin et al. 1984, Ujváry 2010). However, a fatality involving Galicide (a rotenone-based insecticide) produced a calculated lethal dose of 18 mg/lb (40 mg/kg; De Wilde et al. 1986, Ling 2003). The incident involving Galicide involved rotenone mixed with essential oils that would have enhanced absorption by the body and also involved kidney damage that compromised the victim's ability to eliminate the toxins (Ling 2003, De Wilde et al. 1986). However, this fatality was linked to a possible pre-existing condition separate from the Galicide exposure (Ling 2003). Nevertheless, because rotenone formulated as a piscicide is also a mixture to enhance dispersal and absorption, a lethal dose of 18 mg/lb could be assumed in order to be conservative in an effects analysis. At the concentrations applied, a 150 lb (68 kg) person would have to drink a minimum of 28,758 gallons of treated water to obtain a lethal dose, and they might need to drink 215,686 to 359,476 gallons if the lower lethal concentrations are correct. If someone slipped through the closure system and consumed treated water, they would be very unlikely to be harmed. In addition, the rotenone breaks down most rapidly in the presence of light (Schnick 1974) and heat (Dawson et al. 1991). Thus, rotenone in the surface waters where people generally collect drinking water would be the first sites to lose their toxicity.

There was concern expressed by the public about the downstream effects to drinking water. Proposed sites where rotenone would be applied are deep within the wilderness of SEKI. Rotenone is relatively short-lived under typical piscicidal use conditions, dissipating in cold and warm water with half-lives of 20 and 1.5 days, respectively (EPA 2007A). The degradation appears to be driven by aqueous photolysis and hydrolysis and microbial action. Rotenone would be readily neutralized using the oxidizing agent potassium permanganate. In addition, drinking water treatment such as chlorination, ozonation, or charcoal filtering further neutralizes rotenone. The EPA therefore concluded that no chronic exposures to rotenone would occur where water is neutralized with potassium permanganate or treated through a drinking water regimen. Therefore there would be little risk to drinking water sources within or outside the parks as a result of the treatment actions.

The EPA has estimated recreational exposure and risk from swimming in waters where rotenone application has occurred. Although the public would be prohibited from entering waters during rotenone treatment, they may enter waters that were previously treated. Recreational risks were calculated through margins of exposure (MOE), which compare estimated exposure to the no observed adverse effect level in a toxicity study. MOEs >1,000 indicate that recreational exposure risks to rotenone will not exceed the EPA's LOC for dermal, incidental oral, and inhalation risk. Mitigation would be in place to prevent swimmers from entering treated waters until exposures are below the LOC. The EPA estimated that it would take three days in 77 F (25 C) water for rotenone concentrations to decrease below the LOC (for MOE = 1,000, rotenone concentration = 90 ppb). Because waters would be closed to visitors for 3 days following treatment, exposure levels are expected to be below the LOC. Therefore there would be little risk to recreational swimmers from the use of rotenone.

Rotenone exposure from food may occur if humans consume fish that survive a treatment, although this type of exposure is unlikely for wilderness users. The treatment sites would be publicized and visitors would be notified that the areas are undergoing fish removal. This would make them less appealing to anglers. Rotenone has a rapid breakdown rate and a low potential to bioaccumulate in fish (EPA 2007A). In addition, all treated fish would be removed from exposure to the public, by puncturing their swim bladders and sinking carcasses to the substrate within the treatment lake. Therefore there is little likelihood that humans would consume treated fish, and the dietary risk is below the level of concern (EPA 2007A).

General research conducted on the potential effects of rotenone on public health has concluded that rotenone does not cause birth defects, reproductive dysfunction, gene mutations, or cancer (Abdo et al. 1988). When used according to label instructions for the control of fish, rotenone poses little, if any, threat to public health (AFS 2000). There have been public concerns about the link between rotenone use and Parkinson's disease, which likely resulted from an Emory University Study (Betarbet et al. 2000). This study demonstrated that rotenone produced Parkinson's-like symptoms in laboratory rats when administered chronically and intravenously. However the researchers observed that "rotenone seems to have little toxicity when administered orally." The study did not show a cause-and-effect relationship between Parkinson's disease and rotenone exposure.

To prevent the release of rotenone downstream of the treatment areas, potassium permanganate, an oxidizing agent, would be used for neutralization. When applied appropriately, in-stream neutralization poses essentially no risk to human health. Neither rotenone nor potassium permanganate persists in the environment. In California waters within a temperature range of 50 to 68 °F (10 to 20°C), rotenone has been shown to completely degrade within 1 to 8 weeks (CDFG 1994), and to have an estimated half-life of 7.8 to 15 days (Finlayson et al. 2000). Potassium permanganate also has a low estimated lifetime in the environment, being readily converted by oxidizable materials to insoluble manganese dioxide (MnO_2). In turn, MnO_2 is expected to be present for less than 2 days (24 to 48 hours) (FWS 2010) and has a very low bioaccumulative potential. Amounts of rotenone and potassium permanagante are reduced by neutralizing each other, and by quick dissipation in flowing water as a result of dilution, hydrolysis, and photolysis (Finlayson et al. 2000).

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

<u>Employee health and safety:</u> The threats to employee health and safety from gill netting and electrofishing would be the same as described in alternative A.

Crews may be exposed while mixing, loading, or applying rotenone or when entering previously treated areas. Crews applying piscicide treatments have slightly more risk because the undiluted formulation of rotenone (CFT Legumine™) is very concentrated and far more toxic. A 150 lb (68 kg) person could die from drinking 54 ml using 18 mg/lb (40 mg/kg) as the lethal dose. Inhalation may be a greater threat than oral ingestion since intestinal absorption is less likely for water insoluble rotenone (Ling 2003). The state requires that rotenone only be applied by trained and certified applicators. Rotenone containers would be securely locked or guarded when taken to the field for use. Crews would wear appropriate personal protective equipment and a project health and safety plan would be developed and adopted prior to the rotenone application. The EPA (2007A) did not assess risk for occupational activities after rotenone applications because any dermal exposure from collecting dead fish and inhalation exposure from volatilization are expected to be minimal.

For employees, the primary difference in safety between physical and piscicide treatments is “duration of exposure.” It can take up to 6 years to remove all of the fish from a lake, and up to 10 years to remove fish from sites with long or complex streams. Except for the pre and post surveys and planning, restoration of the same sites could have been achieved within two weeks each year for up to three years using piscicide treatments. The difference in exposure may be up to 6 years of summer work per site when physical treatment methods are utilized, versus about two weeks of project work for two years when piscicides are utilized. Because toxic piscicides are involved, the short-term risks to crew safety is low to moderate, but there are long-term benefits due to less exposure to daily hazards.

Cumulative Effects – Alternative B – Health and Safety

Same as alternative A.

Conclusion: This alternative results in no measureable increase in risk for wilderness users, or for crews performing physical treatments. For crews, the short-term risk of piscicide treatments is low to moderate, but the piscicide treatments provide a long-term benefit by reducing total exposure to environmental hazards that would be expected during physical treatments (i.e., an average of 6 summers per lake treatment site and up to 10 summers per site with long or complex streams down to about 2 weeks each year for up to three years for sites selected for piscicide treatment. Piscicide treatments increase the risk for crews slightly, but provide a long-term benefit by reducing total time exposed to work hazards.

Impacts of Alternative C: Physical Treatment Preceding Restoration on Health and Safety

<u>Visitor health and safety:</u> The effects of implementing alternative C to visitor health and safety would be the same as the physical treatment section detailed under alternative A except the duration of the project would be longer and there would be more sites. In addition, blasting would occur (if determined necessary) in up to five locations.

During blasting activities, there would be a slight threat to the wilderness visitor from potential short-term exposure to debris and projectiles in the immediate blasting area. Prior to each detonation, the public would be protected through the use of employees on trails and access routes above and below the work area. In addition, field crews would search for visitors in the area and notify them of the blasting activities. These procedures would temporarily keep visitors out of the blasting area until detonations are completed. Because many of the blasting sites are away from popular visitor use areas, these areas generally have little visitation. Thus, the primary human receptors at risk would be the crew members performing the blasting activities. The risk to visitor safety from blasting is expected to be negligible to low.

<u>Employee health and safety:</u> The effects of this alternative on employee health and safety would be the same as described under alternative A, though the duration of the project would be longer and there would be more project sites, resulting in a slightly increased risk. In addition, blasting would occur (if determined necessary) in up to five locations.

Blasting activities would be implemented by employees trained and certified in the use of blasting. In addition, employees are trained in safety and job hazard analyses that are conducted for each component of the job, reducing the risks. Threats are managed and risks are lowered by proper training, insisting on consistent use of proper equipment and protocols, priority emphasis on group and personal safety, and hiring people who are experienced at sustained living at high elevations and physically fit to do the work safely. In decades of blasting work in support of trail maintenance projects in the parks, no injuries have ever been reported due to blasting activities. The low likelihood of injury is not expected to change under this alternative.

Cumulative Effects – Alternative C – Health and Safety

Same as alternative A.

Conclusion: This alternative presents an increase in risk for crews performing physical treatments because the treatments would be extended over a longer period of time. There would also be a slight increase in risk for crews performing blasting activities (if determined necessary). There would be a negligible to low increase in risk to visitors if blasting occurred.

Impacts of Alternative D: Piscicide Treatment Preceding Restoration on Health and Safety

Visitor health and safety: The effects of this alternative related to the use of piscicide treatments on visitor health and safety are the same as alternative B.

Employee health and safety: The effects of this alternative related to the use of piscicide treatments on employee health and safety are the same as alternative B, except that 52 more waterbodies and 15 more miles of streams would be treated with piscicides, therefore expanding the potential risk to crews performing the treatment activities, but reducing the time crews are exposed to risk from 6 to 10 years per site, to 2 to 4 weeks per site over a 1 to 3 year period.

Cumulative Effects – Alternative D – Health and Safety

Same as alternative A.

Conclusion: This alternative results in no measureable increase in risk for the parks' visitors. Under this alternative, the short-term risk of piscicide treatments to the park employees is low to moderate, but the piscicide treatments provide a long-term benefit by reducing total exposure from up to 6 to 10 years per treatment site (during summer months) to about a two weeks each year for up to three years for piscicide treatment sites. Piscicide treatments increase the risk for crews slightly, but provide a long-term benefit by reducing total project time. Crew exposure to risk does not affect the ability to perform the work safely.

Because of the rapid nature of piscicide treatments, this alternative results in the least exposure to risk for crews for each restoration site. However, because this alternative treats nearly two times as many sites as alternative C, the total risk exposure is probably similar.

VISITOR EXPERIENCE AND RECREATION

Methodology for Analyzing Impacts

NPS *Management Policies 2006* (NPS 2006A) state that the enjoyment of the parks' resources and values by the people of the United States is part of the fundamental purpose of all parks and that the NPS is committed to providing appropriate high-quality opportunities for visitors to enjoy the parks. Part of the purpose of the parks is to offer opportunities for recreation, education, inspiration, and enjoyment. Consequently, one of the parks' goals is to ensure that visitors safely enjoy and are satisfied with the availability, accessibility, diversity, and quality of the parks' facilities, services, and appropriate recreational opportunities.

Each alternative was examined to determine its effect on visitor enjoyment of the parks' resources and opportunities for recreation. Public scoping input and field staff's observation of visitation patterns, combined with assessment of what is currently available to visitors, were used to estimate the relative effects of the alternatives. The potential for change in visitor experience proposed by the alternatives was evaluated by identifying projected increases or decreases in access and other visitor uses, and determining whether or how these projected changes would affect the desired visitor experience, to what degree, and for how long (Table 30). The analysis was also based on whether there would be a loss of a recreation opportunity, a change in access to or availability of a recreation opportunity, or a change in the aggregate of recreation opportunities for the visitor and the degree to which each alternative affects those opportunities.

The primary visitor opportunities affected by the proposed project include opportunities for angling, wildlife watching, and enjoying the parks' resources in their natural setting. Note that impacts related to wilderness use (e.g. opportunities for solitude or primitive and unconfined recreation) are evaluated in the "Wilderness Character" section of chapter 4.

Table 30. Visitor Experience and Recreational Opportunities Impact and Intensity Descriptions

Impact Intensity	Intensity Description
Negligible	Changes in visitor experience and recreational opportunities would be below or at the level of detection. The visitor would not likely be aware of the effects associated with the alternative.
Minor	Changes in visitor experience and recreational opportunities would be barely detectable. The visitor would be aware of the effects associated with the alternative, but would not be concerned with the changes.
Moderate	Changes in visitor experience and recreational opportunities would be readily apparent. The visitor would be aware of the effects associated with the alternative and would likely be able to express an opinion about the changes.
Major	Changes in visitor experience and recreational opportunities would be readily apparent and severely adverse or exceptionally beneficial. The visitor would be aware of the effects associated with the alternative and would likely express a strong opinion about the changes.

Short-term—occurs only during project work.

Long-term—continues after project work.

Impacts of Alternative A: No Action on the Visitor Experience and Recreational Opportunities

From 2001 to 2013, 50,201 nonnative fish were removed from 23 waterbodies as part of the current program. Thirteen of these waterbodies are completed and 10 are nearly completed. In addition, two lakes were eradicated of fish by researchers working under a NPS research permit. Therefore, the total number of affected waterbodies from the removal of nonnative fish as a result of the ongoing program is expected to be 25 waterbodies, with current project work expected to be completed by 2017. Three of the treatment basins contain lakes that are considered destination lakes based on local knowledge, ease of access, and the number of quality lakes. However, none are considered to be quality lakes, where at least 50% of fish captured had a length of at least 10 inches (25 cm; Table 31; data from Knapp R., unpublished data, NPS unpublished data).

Table 31. Treatment Sites and Effects to Angling Opportunities under alternative A

Basin	Lakes[a]	Fish[b]	Length[c]	≥10[d]	Quality [e]	Destination[f]	Distance[g]
Nonnative fish Eradication Completed or In-Progress							
Amphitheater	1	10	8.16	10%	0	No	2.07
Kern Point	2	49	8.82	16%	0	No	2.04
LeConte Canyon	3	57	8.29	19%	0	Yes	0.08
Pinchot	1	30	6.45	0%	0	No	0.69
Sixty Lake	10	485	6.10	1%	0	Yes	0.01
Upper Basin	1	35	9.17	37%	0	No	1.14
Upper Bubbs	3	98	7.01	1%	0	Yes	0.99

[a] The number lakes with gill net data
[b] Number of fish captured in all lakes during a 24 hr gill net set
[c] Average length in inches of fish captured in all lakes during a 24 hr gill net set
[d] Percentage of fish captured ≥ 10 inches during a 24 hr gill net set
[e] Quality is defined as the number of lakes per basin where the percentage of fish captured ≥ 10 inches was ≥ 50% of the total capture
[f] Based on local knowledge, number of quality lakes, and ease of access
[g] Straight line distance (km) to the nearest maintained trail

There would still be 550 waterbodies plus connecting streams contained in 88 basins throughout SEKI that would contain self-sustaining nonnative trout populations, and there would continue to be excellent opportunities for angling in numerous lakes and streams located in wilderness. While individual anglers would be affected if a treatment lake is one of their favorite fishing spots, there are still multiple opportunities for angling throughout the parks. Therefore, this alternative would result in minor to moderate long-term adverse effects on angling opportunities at the selected restoration areas, and no effect on angling opportunities where nonnative fish remain.

This alternative has slightly improved opportunities for other types of recreation, though as stated previously, the current treated sites are generally located away from popular visitor destinations. Regardless, visitors who seek out more remote areas in the wilderness and visit the treated waterbodies have the opportunity to view native wildlife in restored lakes and streams. There would be increased frog populations, aquatic insects, birds and bats that feed on insects, and garter snakes. This increases opportunities for a variety of recreational activities, such as bird watching, photography, and nature study.

The visitor experience in treated areas may be adversely affected by the project work. Under this alternative, there would be up to 13 sites visited or worked each year, most of which are located in remote areas not popular to most visitors. However, visitors to the treatment areas may be disturbed by the work that occurs there, including the netting and electrofishing operations. There generally are not area or lake closures associated with this alternative, but visitors may not want to swim in lakes where gill-netting is ongoing. There could be a beneficial effect on those visitors who would learn more about the restoration program.

Cumulative Effects – Alternative A – Visitor Experience and Recreational Opportunities

The cumulative effects analysis focuses on past, present, and foreseeable future projects that could affect visitor experience and recreational opportunities in the parks' wilderness areas. There are numerous past, ongoing and future projects which may affect visitor experience. Administrative actions, such as building and maintaining trails and ranger stations, research, and resource management, can affect the visitor experience, both in an adverse and positive manner. Visitors may appreciate the work the park is conducting to manage and protect wilderness resources, but also may be disrupted by the presence of work crews and the use of mechanized equipment, which may be used in the wilderness when it is determined to be the minimum tool necessary to conduct work for the purposes of managing the area as wilderness. Cumulative effects on the visitor experience would be negligible to minor and adverse.

Overall, the no action alternative, when considered with past, present, and future potential actions, would slightly add to the adverse cumulative effects associated primarily with disruptions to the visitor experience at treated waterbodies. There would be no cumulative effects on visitor opportunities.

Conclusion: Under the no action alternative, visitors may experience a slight change in recreational opportunities as a result of the ongoing program, primarily due to reduced angling opportunities in the 25 treatment waterbodies. Visitors may experience an increase in recreational opportunities related to the restoration of the native ecosystems. Work crews may disturb some visitors, though some visitors would benefit from learning more about restoration actions in the parks. The adverse and beneficial effects would be negligible to minor based on the limited number of restored sites within the parks, and the remoteness of the treatment areas. Most visitors would not notice the effects associated with this alternative.

Impacts from Elements Common to All Action Alternatives on the Visitor Experience and Recreational Opportunities

<u>Crew camps:</u> Crew camps would be established near project areas. Generally the crew camps would be located away from popular visitor camping areas, and located in such a manner as to be shielded from nearby trails and visitor use areas. Crews would camp in these locations for 10-day shifts, up to 7 times per season. While every effort would be made to avoid popular visitor use areas, there is a potential that crews would be camping in or near a previously used camping spot. Because there would be numerous opportunities nearby for camping, the crew camps would not reduce visitor opportunities for camping in the wilderness. Also, the likelihood of visitors seeing crew camps is slight, and would result in negligible short-term adverse effects to those few park visitors who happen to travel by the site.

<u>Use of Helicopter and Stock:</u> The visitor experience would be adversely affected by the use of helicopters and stock to transport supplies. No restoration crew members would be transported by helicopter except in emergency situations (e.g. accidents or injuries). A helicopter would be used to deliver equipment and supplies to areas inaccessible by stock if determined to be the minimum tool necessary for the administration of wilderness. This means that a maximum of two flights per year would be used to deliver supplies to selected project areas; one round trip in July to mobilize the operation, and one round trip for the end of season pickup in September. The view of the helicopter and the noise generated by the helicopter would detract from the visitor experience for some visitors; others would not be adversely affected. The use of helicopters is readily apparent to those visitors near the flight line or near the project area, creating temporary adverse effects. Therefore, it would result in short-term moderate adverse effects on the visitor experience.

The use of stock to transport supplies would also adversely affect the visitor experience for some visitors and enhance it for others. Stock would travel on trails to the project sites, and could travel cross country if deemed appropriate (considering safety and resource protection). Some wilderness users would be adversely affected by the presence of stock, the noise and dust generated by stock, and by the stock urine and feces left on trails. Other wilderness users would be less affected by the use and presence of stock or not affected at all due to their location or timing of their visit in relation to the stock use, or their perception of stock use. Some visitors do not mind, and even enjoy encountering stock on wilderness trails, while other visitors do not like encountering stock or hiking through areas that exhibit signs of stock use such as manure or dusty trails. Because stock would be used for two round trips per site, the impacts would be difficult to distinguish from other recreational and administrative stock use in the wilderness. Overall, the impact to the visitor experience from the use of stock would be minor short-term and adverse or beneficial.

Restoration of Mountain Yellow-Legged Frogs, Monitoring, and Continuing Research: At any given time within the parks, other aspects of the restoration program would be ongoing. At currently fishless sites and in areas rendered fishless by implementing this plan (up to 55 basins depending on the alternative selected), restoration of the ecosystem could include natural recolonization or reintroduction of native species, and/or a combination of the two. There would also be continuing research and monitoring as part of this project, which would involve the presence of researchers and could involve netting, tagging, and other activities in wilderness. The visitor experience could be adversely affected by the presence of researchers, and by the view of tagging and netting equipment; however most visitors would not notice these activities.

Visitors wishing to have opportunities to view native wildlife in their natural settings would be provided with this opportunity in the restored areas, resulting in long-term beneficial effects. Overall, the short-term effects from the restoration, monitoring, and research program would be negligible to minor and adverse, but the long-term effects would be beneficial as additional ecosystems are restored.

Fish Disposal: Nonnative fish removed from selected lakes and streams would be disposed of by sinking the fish in the treatment lakes. Most visitors would not notice the presence of the dead fish, but a few visitors may be in the project area during the disposal activities and be disturbed by the disposal activities, including the sight and smell of dead fish. This effect is short-term, until fish are sunk in deep waters. Therefore, the effects to the visitor experience would be short-term negligible to minor and adverse.

Conclusion: The overall effects on the visitor experience as a result of the elements common to all alternatives is short- to long-term, negligible to moderate and adverse, and long-term and beneficial.

Cumulative Effects from Elements Common to All Action Alternatives – Visitor Experience and Recreational Opportunities

At any given time in the wilderness, there could be ongoing administrative activities that require the establishment of temporary crew camps. While most crew camps are small, with generally 2 to 6 people, trail crew camps can include 20 people. The crew number combined at any given time in the wilderness during summer months can total more than 100 people. However, these crews are spread throughout the parks' wilderness (more than 808,000 ac/327,000 ha), and, other than the large trail crews, the likelihood of the average wilderness user seeing or identifying the smaller work crews is low. Generally all work crews camp away from the primary backpacker camp areas/sites, and the larger trail crews usually have separate camps away from the public use areas. Though visitors may experience a decrease in solitude from the presence of work crews (as discussed under the Wilderness Character section), there would be no decrease in recreational opportunities as a result of crew camps, and thus there would be no cumulative effects.

There are a number of flights that occur in the wilderness each year associated with the administration of wilderness. Also, stock use for administrative purposes occurs each summer to support wilderness operations. When considering the infrequent flights that would occur as a result of any of the alternatives (maximum two per year per location), the infrequent use of stock (two trips per year per location), and the minimal sound of small work crews (typically two to three people at each project site), the project activities associated with the actions common to all action alternatives would result in short-term minor to moderate cumulative effects.

Each year, there can be 60 to 90 research permits issued for wilderness research. In addition, there are a number of resource management projects that occur in wilderness. The presence of scientists and resource managers is not noticeable to most visitors. Those who notice the presence of scientists and resource managers may be adversely affected if the visitors do not want to see this type of activity. In the long-term it may improve the visitor experience as more knowledge is gained and areas are restored and/or management is improved. The cumulative effects would be short-term, minor, and adverse, and long-term and beneficial. There are no other fish disposal activities planned in the wilderness in the foreseeable future, therefore there would be no cumulative effect.

Impacts of Alternative B: Prescription Treatment Preceding Restoration (Preferred Alternative) on the Visitor Experience and Recreational Opportunities

This alternative would remove angling waters in 21 treatment basins, including 85 waterbodies (31 lakes, 49 ponds, 5 marshes), approximately 31 mi (50 km) of streams, plus connected fish-containing habitat as necessary. Under alternative B, six of the treatment basins have lakes or streams that could be considered "destination" areas for angling, and one lake is considered a quality fishing lake, where at least 50% of fish captured had a length of at least 10 inches (25 cm; Table 32; data from Knapp R., unpublished data, NPS unpublished data). The park lacks inventory data on fish populations in streams, but fish seem to be present in most mapped streams. Assuming the presence of fish in most or all mapped streams, this alternative would affect 0.8% to 1% of fish populations in streams in SEKI.

Overall, this alternative creates a negligible to minor impact on angling parkswide, but a major adverse effect on individual anglers who enjoy fishing at the specific lakes selected for nonnative fish removal.

Opportunities for wildlife viewing would increase in time at the treated sites. Visitors to lakes without nonnative fish would observe increasing numbers of open-water aquatic insects, birds and bats that feed on insects, and garter snakes.

Visitors to the project areas would incur short-term inconvenience (7 to 14 days) as piscicide treatments are implemented making some water sources unavailable to drinking. Lakes and streams would be closed to visitor use during the treatment periods.

The visitor experience in treatment areas may be adversely affected by the presence of work crews and the project work in up to six treatment sites per year in the parks, some of which are located in remote, not very popular areas. Visitors to the treated areas may be disturbed by the work that occurs there, including the netting and electrofishing operations, and piscicide treatments. There also could be a beneficial effect on those visitors who would learn more about the restoration program and the effects of the program on native species and ecosystems.

Table 32. Treatment Sites and Effects to Angling Opportunities under alternative B

Basin	Lakes[a]	Fish[b]	Length[c]	≥ 10[d]	Quality[e]	Destination[f]	Distance[g]
Physical Treatment							
Barrett	3	82	8.05	14.6%	1	No	2.16
Blossom	na	na	na	na	na	Yes	0.01
Brewer	na	na	na	na	na	No	1.93
Crytes	na	na	na	na	na	No	2.39
Dusy	1	29	7.97	0.0%	0	Yes	0.03
East Wright	1	108	6.80	2.8%	0	No	2.28
Horseshoe	4	30	7.41	13.3%	0	No	0.00
McGee	4	207	7.28	0.0%	0	No	1.21
Milestone	2	28	7.66	0.0%	0	No	0.66
Rambaud	1	78	7.01	0.0%	0	No	1.82
Slide	1	37	7.70	8.1%	0	No	2.13
Swamp	na	na	na	na	0	No	3.80
Tablelands	na	na	na	na	na	Yes	0.23
Upper Bubbs	2	117	6.36	0.0%	0	Yes	0.13
Upper Evolution	3	84	8.09	4.8%	0	Yes	0.00
Upper Kern	na	na	na	na	0	No	1.13
Vidette	1	6	8.59	16.7%	0	No	2.18
Piscicide Treatment							
Amphitheater	1	43	7.35	0.0%	0	No	0.68
Crescent	na	na	na	na	na	No	0.00
Crytes	na	na	na	na	na	No	1.19
Horseshoe	4	30	7.41	13.3%	0	No	0.42
Laurel	na	na	na	na	na	No	2.19
Sixty Lake	10	479	5.33	0.0%	0	Yes	0.53
Upper Bubbs	na	na	na	na	na	Yes	0.12
Upper Evolution	3	84	8.09	4.8%	0	Yes	0.02
Upper Kern	2	72	7.24	1.4%	0	No	0.70

[a] The number lakes with gill net data
[b] Number of fish captured in all lakes during a 24 hr gill net set
[c] Average length in inches of fish captured in all lakes during a 24 hr gill net set
[d] Percentage of fish captured ≥ 10 inches during a 24 hr gill net set
[e] Quality is defined as the number of lakes per basin where the percentage of fish captured ≥ 10 inches was ≥ 50% of the total capture
[f] Based on local knowledge, number of quality lakes, and ease of access
[g] Straight line distance (km) to the nearest maintained trail

Cumulative Effects – Alternative B - Visitor Experience and Recreational Opportunities

As stated under alternative A, there are a number of activities that occur in the parks that can affect the visitor experience. Overall, alternative B, when considered with past, present, and future potential actions, would slightly add to the adverse cumulative effects associated primarily with disruptions to the visitor experience from project work. Cumulative effects to the visitor experience would be negligible to minor and adverse.

Conclusion: Under alternative B, visitors would experience a moderate change in recreational opportunities as a result of expanding the existing program, primarily due to reduced angling opportunities in the 21 additional treatment basins. Visitors may experience an increase in recreational opportunities related to the restoration of the native ecosystems. Work crews may disturb some visitors, though some visitors would benefit from learning more about restoration actions in the parks. Visitors to the restored waterbodies should notice the effects associated with this alternative. Effects would be short- and long-term minor to moderate and adverse and beneficial.

Impacts of Alternative C: Physical Treatment Preceding Restoration on the Visitor Experience and Recreational Opportunities

Physical treatment would be used for 52 waterbodies (27 lakes, 24 ponds, 1 marsh) and approximately 15 mi (25 km) of streams in 17 basins. Five of the treatment basins have lakes that are considered destination areas for anglers, with one of the lakes considered a quality fishing lake. This alternative would remove opportunities for angling at these locations, and slightly reduce opportunities for angling parkswide. Overall this alternative creates a negligible to minor effect on angling opportunities parkswide, but may create a major adverse effect to individual anglers who enjoy fishing at one of the lakes selected for nonnative fish removal (Table 33).

This alternative would have similar effects on recreational opportunities and the visitor experience as alternative B except that: (1) fewer basins would be treated, (2) the project would be longer in duration since all of the work would be done with gill nets and electrofishers, (3) effects to angling parkswide are slightly less with fish being removed from 9% of the lakes with fish, and from 0.2% to 0.4% of the parks mapped stream miles containing fish, (4) piscicides would not be used to treat any of the sites, negating the need for multi-day closures during treatment, and (5) blasting would occur (if determined necessary) in up to five locations. In the long-term, there would be fewer opportunities for observing native wildlife and nature study than under alternatives B and D.

Cumulative Effects – Alternative C - Visitor Experience and Recreational Opportunities

As stated under alternative A, there are a number of activities that occur in the parks that can affect the visitor experience. Overall, alternative C, when considered with past, present, and future potential actions, would slightly add to the adverse cumulative effects associated primarily with disruptions to the visitor experience from project work. There would be no cumulative effects on visitor opportunities. Cumulative effects to the visitor experience would be negligible to minor and adverse.

Conclusion: Under alternative C, visitors would experience a negligible to minor change in recreational opportunities as a result of expanding the existing program, primarily due to reduced angling opportunities in the 17 treatment basins. Visitors may experience an increase in wildlife viewing opportunities as a result of the restoration of native ecosystems. Work crews may disturb some visitors, though some visitors would benefit from learning more about restoration actions in the parks. The adverse effects would be long-term, negligible to minor based on the number of restored sites within the parks, and the remoteness of the treatment areas. Visitors to the restored waterbodies should notice the effects associated with this alternative. Effects would be short- and long-term minor to moderate and adverse and beneficial.

Table 33. Treatment Sites and Effects to Angling Opportunities under alternative C

Basin	Lakes[a]	Fish[b]	Length[c]	≥ 10[d]	Quality [e]	Destination[f]	Distance[g]
Physical Treatment							
Barrett	3	82	8.05	14.6%	1	No	2.16
Blossom	na	na	na	na	na	Yes	0.01
Brewer	na	na	na	na	na	No	1.93
Crytes	na	na	na	na	na	No	2.39
Dusy	1	29	7.97	0.0%	0	Yes	0.03
East Wright	1	108	6.80	2.8%	0	No	2.28
Horseshoe	4	30	7.41	13.3%	0	No	0.00
McGee	4	207	7.28	0.0%	0	No	1.21
Milestone	2	28	7.66	0.0%	0	No	0.66
Rambaud	1	78	7.01	0.0%	0	No	1.82
Slide	1	37	7.70	8.1%	0	No	2.13
Swamp	na	na	na	na	0	No	3.80
Tablelands	na	na	na	na	na	Yes	0.23
Upper Bubbs	2	117	6.36	0.0%	0	Yes	0.13
Upper Evolution	3	84	8.09	4.8%	0	Yes	0.00
Upper Kern	na	na	na	na	0	No	1.13
Vidette	1	6	8.59	16.7%	0	No	2.18

[a] The number lakes with gill net data
[b] Number of fish captured in all lakes during a 24 hr gill net set
[c] Average length of fish in inches captured in all lakes during a 24 hr gill net set
[d] Percentage of fish captured ≥ 10 inches during a 24 hr gill net set
[e] Quality is defined as the number of lakes per basin where the percentage of fish captured ≥ 10 inches was ≥ 50% of the total capture
[f] Based on local knowledge, number of quality lakes, and ease of access
[g] Straight line distance (km) to the nearest maintained trail

Impacts of Alternative D: Piscicide Treatment Preceding Restoration on the Visitor Experience and Recreational Opportunities

Under alternative D, piscicide treatment would be used for 85 waterbodies (31 lakes, 49 ponds, 5 marshes) and approximately 31 mi (50 km) of streams, plus connected fish-containing habitat as necessary, contained in 21 basins. Under alternative D, six of the treatment basins have lakes that are considered destination areas for angling, with one lake considered a quality fishing lake. This would result in the elimination of opportunities for angling at these locations, and slightly reducing opportunities for angling parkswide. Overall this alternative creates a long-term negligible to minor adverse effect on angling opportunities parkswide, but may create a major adverse effect on individual anglers who enjoy fishing at one of the lakes selected for nonnative fish removal (Table 34).

This alternative would have similar effects to recreation as alternative B except that since all of the work would be done with piscicides, the project duration would be shorter.

Table 34. Treatment Sites and Effects to Angling Opportunities under alternative D

Basin	Lakes[a]	Fish[b]	Length[c]	≥ 10[d]	Quality [e]	Destination[f]	Distance[g]
Piscicide Treatment							
Amphitheater	1	43	7.35	0%	0	No	0.68
Barrett	3	82	8.05	15%	1	No	2.16
Blossom	na	na	na	na	na	Yes	0.01
Brewer	na	na	na	na	na	No	1.93
Crescent	na	na	na	na	na	No	0.00
Crytes	na	na	na	na	na	No	1.19
Dusy	1	29	7.97	0%	0	Yes	0.03
East Wright	1	108	6.80	3%	0	No	2.28
Horseshoe	4	30	7.41	13%	0	No	0.00
Laurel	na	na	na	na	na	No	2.19
McGee	4	207	7.28	0%	0	No	1.21
Milestone	2	28	7.66	0%	0	No	0.66
Rambaud	1	78	7.01	0%	0	No	1.82
Sixty Lake	10	479	5.33	0%	0	Yes	0.53
Slide	1	37	7.70	8%	0	No	2.13
Swamp	na	na	na	na	0	No	3.80
Tablelands	na	na	na	na	na	Yes	0.23
Upper Bubbs	2	117	6.36	0%	0	Yes	0.12
Upper Evolution	3	84	8.09	5%	0	Yes	0.00
Upper Kern	2	72	7.24	1%	0	No	0.70
Vidette	1	6	8.59	17%	0	No	2.18

[a] The number lakes with gill net data
[b] Number of fish captured in all lakes during a 24 hr gill net set
[c] Average length of fish in inches captured in all lakes during a 24 hr gill net set
[d] Percentage of fish captured ≥ 10 inches during a 24 hr gill net set
[e] Quality is defined as the number of lakes per basin where the percentage of fish captured ≥ 10 inches was ≥ 50% of the total capture
[f] Based on local knowledge, number of quality lakes, and ease of access
[g] Straight line distance (km) to the nearest maintained trail

Cumulative Effects
The cumulative impacts would be the same as alternative B.

Conclusion: Impacts would be similar to alternative B except that this alternative would result in a greater number of short-term site closures, and take the least amount of time to complete, meaning that angling would be excluded sooner and opportunities for observing wildlife would improve faster when compared to the other alternatives.

SUSTAINABILITY AND LONG-TERM MANAGEMENT

In accordance with the NEPA and as further explained in *Director's Order 12: Conservation Planning, Environmental Impact Analysis, and Decision-making* (DO-12), consideration of long-term impacts and the effects of foreclosing future options should pervade any NEPA document. According to DO-12, and as defined by the World Commission on Environment and Development, "sustainable development is that which meets the needs of the present without compromising the ability of future generations to meet their needs." For each alternative considered in an EIS, considerations of sustainability must demonstrate the relationship between local short-term uses of the environment and the maintenance and enhancement of long-term productivity. This relationship is described below for each alternative.

The NPS must consider if the effects of the project alternatives involve tradeoffs in the long-term productivity and sustainability of parks resources for the immediate short-term use of those resources. It must also consider if the effects of the alternatives are sustainable over the long term without causing adverse environmental effects for future generations (NEPA section 102(c)(iv)).

Under all of the alternatives most of the parks would continue to be protected and would continue to be used by the public. The NPS would continue to manage the parks under all the alternatives to maintain ecological processes and native and biological communities, and to provide for appropriate recreational activities consistent with the preservation of natural and cultural resources. Strategies for accomplishing these goals will be outlined in detail in the SEKI *Resource Stewardship Strategy* which is scheduled to be completed in late 2016.

Alternative A (No Action): Existing High Elevation Restoration Efforts would continue through 2017.

Alternative A would trade off the short-term uses of the parks resources for long-term productivity. When the ongoing project is completed, nonnative fish would be removed from 23 waterbodies by parks staff and 2 waterbodies by researchers, with restoration occurring in a total of 25 waterbodies, in effect restoring the natural processes of those waters and removing fishing opportunities from those aquatic ecosystems. Monitoring and conservation of native species would continue to occur over time in all 25 waterbodies.

Fishing opportunities would continue in the short- and long-term in 550 lakes plus connecting streams contained in 88 basins; however, reproducing nonnative fish would continue to compromise the long-term productivity of native species in those areas. Nonnative fish would remain in naturally fishless lakes over the long term.

Alternative B: Prescription Treatment (Physical and Piscicide) Preceding Restoration (NPS Preferred Alternative)

Alternative B would result in a detailed plan of action to restore high elevation ecosystems by removing nonnative fish where feasible. Aquatic ecosystem restoration would occur in 55 basins. Nonnative fish would be eradicated from selected waterbodies in 21 basins and approximately 31 mi (50 km) of streams. Removals would occur over the next 25 to 35 years, and would include the use of physical removal methods and treatment with piscicides. While there would be some short-term losses in biological productivity (e.g., losses of some macroinvertebrate species) due to piscicide use, this would be offset by the increase in long-term biological productivity. Following removal, native species, such as the MYLF would be restored to these areas. If successful, this alternative would result in the enhancement of the long-term productivity of SEKI's high elevation aquatic ecosystems. Even if the MYLF does not survive, the native aquatic ecosystem would be more productive and resilient to climate change (NPS 2010A).

There would continue to be fishing opportunities for the short- and long-term in 465 waterbodies plus connecting streams contained in 69 basins within SEKI. Reproducing nonnative fish would continue to compromise the long-term productivity of native species in those areas. Nonnative fish would remain in naturally fishless lakes over the long term.

To be sustainable, this project would require long-term management, including eradication efforts and monitoring for the next 25 to 35 years. These actions would require periodic commitment of funds and personnel for the foreseeable future to ensure success.

Alternative C: Physical Treatment Preceding Restoration

Alternative C would use physical treatment methods only to eradicate nonnative fish by gill netting, electrofishing, trapping, disruption and/or covering of redds, and blasting rock to create vertical fish barriers. In comparison to alternative B, excluded from the list of proposed restoration waters are long reaches of stream, most large lakes, and interconnected lake complexes that are too large for effective physical treatment. This alternative would restore 52 waterbodies and approximately 15 mi (25 km) of streams in 17 basins. When compared with alternative B, there would be fewer fishless areas, thus less potential for the enhancement of long-term productivity. There would be additional opportunities for fishing in the short- and long-term, but reproducing nonnative fish would continue to compromise the long-term productivity of native species in 498 waterbodies plus connecting streams contained in 80 basins. Nonnative fish would continue to remain in naturally fishless lakes over the long term.

Similar to alternative B, this project would require long-term management, including eradication efforts and monitoring for the next 25 to 35 years. These actions would require periodic commitment of funds and personnel for the foreseeable future to facilitate success.

Alternative D: Piscicide Treatment Preceding Restoration

Alternative D emphasizes speed in recovering habitat because MYLF populations are declining rapidly. To achieve this speed, only piscicide treatment would be used for nonnative fish eradication. Properly applied, piscicides can eliminate fish from targeted waterbodies in as few as 1 to 3 years, in contrast to physical treatment which can take up to 6 years for lakes and up to 10 years for long or complex streams (NPS 2012A). A prescription for treatment would be developed as described in alternative B. Based on existing information, piscicide treatment would be used for 85 waterbodies and approximately 31 mi (50 km) of streams contained in 21 basins. This alternative would result in additional short-term effects to productivity resulting in additional waterbodies treated by piscicides, it would enhance long-term productivity of high elevation aquatic ecosystems, and the approach would take considerably less time to implement.

There would be additional opportunities for fishing in the short- and long-term, but reproducing nonnative fish would continue to compromise the long-term productivity of native species in 465 waterbodies plus connecting streams contained in 69 basins. Nonnative fish would continue to remain in naturally fishless lakes over the long term.

Similar to alternative B, this project would require long-term management, but eradication efforts would be completed in 15 to 20 years, and monitoring would continue for the next 25 to 35 years. These actions would require periodic commitment of funds and personnel for the foreseeable future to ensure success.

Estimated Costs of Each Alternative

From 1997 to 2015, restoration of high elevation aquatic ecosystems in SEKI has included removal of nonnative fish from 25 waterbodies and 3.7 mi (6.0 km) of stream using physical methods (gill netting, electrofishing, and disruption and/or covering of redds). Researchers eradicated fish in 2 waterbodies by 1999, and the NPS eradicated fish from 13 waterbodies and approximately 2 miles of stream by 2015. The NPS has fish eradication work in-progress in the remaining 10 waterbodies and approximately 1.2 mi of stream.

The NPS expects to eradicate fish in seven of the in-progress waterbodies by 2017. The NPS eradicated fish in three in-progress waterbodies by 2007 but insufficient barriers (small non-vertical natural cascades) are allowing fish to recolonize each summer. Habitat below these three waterbodies is proposed for nonnative fish eradication in this Restoration Plan/FEIS, which would allow these waterbodies to be completed and thus retained as fishless habitat. If this habitat is selected for eradication in the Final EIS and Record of Decision for this Restoration Plan, then these final in-progress waterbodies would also be eradicated of fish once further restoration work is approved and completed.

The Final EIS and Record of Decision for this Restoration Plan are estimated for completion in 2016. At that time, there would be 10 waterbodies and approximately 1.2 mi of stream with in-progress fish eradications, which are expected to be completed by 2017. Therefore, the costs estimated for alternative A (no action) include two more years of work (from 2016 to 2017) needed to complete existing physical fish eradication treatments at 10 waterbodies and approximately 1.2 mi of stream (Table 35).

The costs estimated for alternative B (Prescription Treatment Preceding Restoration) include 30 years (from 2016 to 2045) of physical and piscicide fish eradication treatments at an additional 85 waterbodies and approximately 31 mi (50 km) of stream, piscicide effects studies, and MYLF recovery actions. The costs estimated for alternative C (Physical Treatment Preceding Restoration) include 30 years (from 2016 to 2045) of physical fish eradication treatments at an additional 52 waterbodies and approximately 15 mi (25 km) of stream, and MYLF recovery actions. The costs estimated for alternative D (Piscicide Treatment Preceding Restoration) include 20 years (from 2017 to 2036) of piscicide fish eradication treatments at an additional 85 waterbodies and approximately 31 mi (50 km) of stream, and piscicide effects studies; and 30 years (from 2016 to 2045) of MYLF recovery actions.

Table 35. Estimated costs of each alternative

Alternatives	Annual Budget Cost Estimate[1]	Total Budget Cost Estimate
Alternative A: (No Action) • includes 2 years (from 2016 to 2017) of completing existing physical fish eradication treatments at 10 waterbodies and approximately 1.2 mi (1.9 km) of stream.	$113,639 to $114,776	$228,415
Alternative B: Prescription Treatment Preceding Restoration • includes 30 years (from 2016 to 2045) of physical and piscicide fish eradication treatments at an additional 85 waterbodies and approximately 31 mi (50 km) of stream, piscicide effects studies, and MYLF recovery actions.	$154,242 to $279,921	$6,858,047
Alternative C: Physical Treatment Preceding Restoration • includes 30 years (from 2016 to 2045) of physical fish eradication treatments at an additional 52 waterbodies and approximately 15 mi (25 km) of stream, and MYLF recovery actions.	$154,242 to $205,837	$5,365,291
Alternative D: Piscicide Treatment Preceding Restoration • includes 20 years (from 2017 to 2036) of piscicide fish eradication treatments at an additional 85 waterbodies and approximately 31 mi (50 km) of stream, and piscicide effects studies; and 30 years (from 2016 to 2045) of MYLF recovery actions.	$20,000 to $141,611	$2,656,880

[1] Amounts shown are the range of annual costs over the life of the alternative, from the year with the lowest cost to the year with the highest cost. Annual costs over the life of each alternative include an estimated inflation rate of 1% per year.

Project Funding
Completed and ongoing project work has been funded by a combination of competitive funding sources (~90%) including the NPS Natural Resources Preservation Program (NRPP) and grant moneys, NPS base funding (~10%), and donations (<1%). For future project work, the NPS would implement approved project work by securing additional funds from competitive funding sources and / or by seeking an increase in NPS base funding. The NPS expects to be competitive in securing project funding given the significance of the high Sierran ecosystems involved, the urgent need to recover endangered MYLFs, ongoing adverse effects of nonnative fish on aquatic ecosystems, demonstrated benefits from completed fish eradications, and the potential for substantial net ecosystem benefit from fish eradication and active frog restoration actions proposed in this Restoration Plan/FEIS. Therefore, the NPS would implement the selected action in the Restoration Plan over time at a level compatible with available funding.

ADVERSE IMPACTS THAT COULD NOT BE AVOIDED

The NPS is required to consider if the alternative actions would result in impacts that could not be fully mitigated or avoided (NEPA section 101(c)(ii)).

Under all of the alternatives, nonnative fish would continue to occupy habitat within SEKI resulting in an adverse impact to high elevation native ecosystems that cannot be fully mitigated or avoided. Currently 560 high elevation waterbodies are known to contain reproducing nonnative fish. Each of the alternatives would result in a decrease in nonnative fish in treated lakes, streams, and associated marshes.

- Alternative A, 550 waterbodies would remain untreated;
- Alternative B, 465 waterbodies would remain untreated;
- Alternative C, 498 waterbodies would remain untreated; and
- Alternative D, 465 waterbodies would remain untreated.

As stated in the “Environmental Consequences” section, the presence of nonnative fish species results in short- and long-term adverse effects to native populations of vertebrates and invertebrates.

While all of the alternatives result in some level of restoration of native species to selected high elevation basins, the large scale loss of MYLFs in the Sierra Nevada including areas within SEKI cannot be completely mitigated or resolved by any of the alternatives. MYLFs have disappeared from 92% of their historic localities in the Sierra Nevada, including many localities within SEKI. Populations that remain are heavily fragmented; areas in which MYLF populations have disappeared are likely too far from existing populations to be naturally recolonized by migrating frogs. In addition, many of the remaining MYLF populations are restricted by fish to small shallow ponds vulnerable to drying and warming. The restoration efforts would: (1) establish large, connected complexes of fishless habitat, (2) treat MYLFs for disease, and (3) and conduct a suite of active restoration methods to stabilize and recover extant MYLF populations and re-establish MYLF populations that recently died out, thereby mitigating these extensive losses and impacts in up to 55 basins, depending on the alternative selected.

All of the alternatives include fish removal efforts that may have unavoidable short-term adverse impacts on some native birds (gill netting has resulted in infrequent bird mortality). Alternatives B and D consider the use of piscicides as a tool to remove nonnative fish from selected waters. The use of piscicides would result in major and adverse short-term effects to gill-breathing organisms which cannot be avoided or completely mitigated. 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. As described in chapter 4, invertebrate recovery can occur within as little as 2 months or could take more than 5 years depending on a variety of factors.

Under all the alternatives, project work would adversely affect wilderness character because of the trammeling actions and development associated with project work, and reduction in opportunities for solitude resulting from the presence of work crews. In addition, equipment and activities may disrupt visitors, and some visitors may find their favorite fishing area is a targeted fish removal area, thus eliminating their opportunities for fishing in that area.

IRREVERSIBLE OR IRRETRIEVABLE COMMITMENT OF RESOURCES

The NPS must consider if the effects of the alternatives cannot be changed or are permanent (that is, the impacts are irreversible). The NPS must also consider if the impacts on park resources would mean that once gone, the resource could not be replaced; in other words, the resource could not be restored, replaced, or otherwise retrieved (NEPA section 102(c)(v)). Under all the alternatives, there would continue to be long-term impacts on the parks' resources from the presence of nonnative trout in naturally fishless high elevation aquatic ecosystems. These fish populations are self-sustaining and continue to have permanent, adverse impacts on native biota, and could result in the elimination of some species of native aquatic organisms. Once permanently gone from lakes, even with the removal of nonnative fish, some of the aquatic species may not be restored or replaced. At the landscape scale, where restoration activities are implemented and successful, populations of these organisms may remain viable in other lakes or habitat where fish are not present.

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CHAPTER 5 - CONSULTATION AND COORDINATION

PUBLIC SCOPING

On January 17, 2007, Sequoia and Kings Canyon National Parks released a public scoping brochure for the Restoration of Mountain Yellow-legged Frogs and High Elevation Lakes and Streams environmental analysis (appendix D). The brochure included background information on the proposed project, several preliminary alternatives, and a scoping comment form to assist the public with providing scoping comments. The scoping brochure was mailed to approximately 100 individuals, tribes, organizations, and agencies on the parks' mailing list. A news release announcing public scoping was also distributed to approximately 135 media outlets. Public scoping was conducted from January 17 to February 6, 2007, but comments were accepted as late as April. During that time, the parks received comments from 35 different sources (several people submitted more than one comment letter). Six of the comment letters received were from organizations: High Sierra Hikers Association, Wilderness Watch, California Trout, Californians for Western Wilderness, National Parks Conservation Association, and Californians for Alternatives to Toxics. Five commenters were affiliated with universities, three with businesses, one was affiliated with the USFS, and the parks received 22 comments from unaffiliated individuals.

In late 2007, a newsletter providing an update on the environmental analysis status was sent to approximately 100 individuals, agencies, interest groups, and tribes on the parks' mailing list including all those who provided comments during the scoping period. As a result of the newsletter, four additional comment letters were received between May 2007 and November 2008 and are included in the record. Two of those letters were from unaffiliated individuals (one had previously submitted comments), and two were from organizations, Western Environmental Law Center and High Sierra Hikers Association (previously submitted comments). In total, 37 different individuals, groups, businesses, or agencies submitted comments on the proposed project. Commenters provided input by a variety of methods, including letters, email, and completing and submitting the form provided by the parks. All comments received were entered into the NPS Planning, Environment, and Public Comment (PEPC) system and are a part of the public record.

Each comment letter was reviewed by the parks staff to determine the potential issues and impact topics related to the proposed project. Some of the comments provided staff with additional materials and data to assist with the preparation of the environmental document. In late 2007, park staff began writing an environmental assessment for the proposed project. As staff prepared the EA, including the environmental analysis for the proposed project, and re-reviewed the public input on the proposal, it became clear that the project had the potential for significant impacts on the human environment. There was a level of controversy associated with the proposal, the potential for uncertain and potentially significant environmental effects (beneficial and adverse), and that the project could result in unique and unknown environmental effects. For these reasons, in accordance with the National Environmental Policy Act (NEPA) section 102 (2) (C), in early 2009, the superintendent determined that an Environmental Impact Statement (EIS) would be more appropriate for this project.

A notice of intent to prepare an environmental impact statement was published in the *Federal Register* for this project on October 7, 2009. Scoping occurred from October 7 through November 21, 2009. Simultaneously, the NPS provided information on the proposed project with a press release (appendix D) and/or letter by email or mail to more than 380 individuals, interest groups, agencies, and businesses on the parks' mailing list, and to 32 area tribes or tribal representatives. An additional press release was sent to the same mailing list informing the public about public informational meetings on the proposed project, which were held on November 5 in Three Rivers, CA and on November 13 in Fresno, CA. Information about the project scoping was picked up by the Associated Press and was published in area newspapers and on the internet on various public and government websites. Area newspapers that published stories related to the proposed project and scoping include: The Kaweah Commonwealth (October 30), The Visalia Times Delta (October 27), and The Fresno Bee (October 26). Websites included: abclocal.go.com (October 26); cbs13.com (October 26); mercedsunstar.com (October 26); kcbs.com (October 26); fresnobee.com (October 26); ksrw.sierrawave.net (October 7); Save the Frogs (November 18); treehugger.com (November 22); National Parks Traveler (November 20); Sierra Forest Legacy (November 12); and redding.com (October 30). Also the story was broadcast on "The California Report" (November 16), which airs on various local radio stations in California. In addition, further information was provided on the proposed project after scoping ended at Golden Gate Press (December 3) and at alternatives2toxics.org (December 16).

Two public informational meetings were held to provide information on the proposed project during the scoping period. The parks' Aquatic Ecologist provided a presentation with background information on the proposal. The public was invited to ask questions and discuss issues during the presentations. There were 17 participants at the Three Rivers meeting and eight participants at the Fresno meeting. All information and questions provided by participants was documented and is included in this scoping report.

SEKI received 709 comment letters during the scoping period. Commenters provided input by a variety of methods, including letters, email, hand delivery, and through the NPS PEPC system. All comments received were entered into the PEPC database and are a part of the public record.

In addition to the scoping meetings, alternatives presentations and workshops were held in the area to engage the public during the development of alternatives. All scoping commenters plus those on the project mailing list were notified of the meetings (approximately 1,000 people) by either email or regular mail. The meetings were held on March 23, 2010, in Visalia, California (no attendees), on March 30, 2010 in Bishop, California (eight attendees), and on April 5, 2010, in Three Rivers, California at the monthly Town Hall meeting (approximately 40 attendees). Between March 11 and April 12, 2010, draft conceptual alternatives were made available from the parks' internet page and through PEPC, and comments were accepted and considered on those alternatives. Eight comment letters were received during the alternatives review period; none provided new alternatives or additional new substantive comments.

Public Review of the Restoration Plan/DEIS

The Restoration Plan/DEIS (NPS 2013A) was available to the public, federal, state, and local agencies, tribes, and organizations for a 60-day public review period starting September 26, 2013. A Notice of Availability (NOA) was published in the Federal Register on October 1, 2013. The NPS posted electronic copies of the Restoration Plan/DEIS to the NPS Planning, Environment, and Public Comment (PEPC) website at http://parkplanning.nps.gov/aquatics and provided printed or CD copies of the Restoration Plan/DEIS to 138 interested parties on the parks' mailing list and to those who requested them. A printed copy was provided to 23 area public libraries in Tulare, Inyo, Fresno, and Kern counties. In addition, notification of the Restoration Plan/DEIS was sent by email or regular U.S. mail to 1,309 people on the parks' mailing list. A news release was distributed to media outlets, and was placed on the parks' website. In October 2013, due to an extended shutdown of the federal government, and the unavailability of federal systems that allowed the review of the draft plan, the public review period was extended to December 17, 2013. The extension notice was published in the Federal Register on November 1, 2013.

Park staff presented elements of the Restoration Plan/DEIS at three public meetings (in Fresno, Three Rivers, and Bishop, CA). Total attendance at the public meetings was 39. Park staff also presented elements of the Restoration Plan/DEIS at one meeting between Sierra National Forest staff and area tribes.

The public meeting schedule was as follows:

- November 19, 2013: University of California-Merced, Fresno Center, Fresno, CA
- November 20, 2013: Three Rivers Arts Center, Three Rivers, CA
- November 21, 2013: Eastern Sierra Tri-county Fairgrounds, Bishop, CA

The NPS received public comment letters through the PEPC system, by fax, U.S. mail, and hand delivery. The full text of public comment letters received can be viewed on the project website at: http://parkplanning.nps.gov/aquatics. Personal information included with the comments (e.g., names and contact information) is redacted in the correspondence posted online to protect individuals' privacy. Information is included if the comment was submitted by agencies, tribes, businesses, and organizations.

During the public review period, the parks received 123 public comment letters: 116 from individuals; 4 from federal, state, county, or local governments; 1 from a tribe; and 2 from recreational or conservation-related interest groups. The analysis of these letters identified 359 discrete comments, from which 48 concern statements were generated. The results of the public comment analysis process and the NPS responses to substantive public comments are provided in "Appendix E: Public Comment Concern/Response Report."

CONSULTATION AND PERMITTING REQUIREMENTS

The Endangered Species Act of 1973, as amended (16 USC 1531 et seq.), requires all federal agencies to consult with the FWS to ensure that any action authorized, funded, or carried out by the agency does not jeopardize the continued existence of listed species or critical habitat. The NPS reviewed the special-status species lists on the FWS website in 2006, 2009, 2012, and again on February 10, 2016 (see appendix F). The NPS initiated several discussions with various FWS staff including several phone, email, and in-person communications to (1) describe this project and its potential relationships to special-status species; (2) become educated on the consultation process and timeline; and (3) determine an appropriate consultation structure. The phone and email communications occurred intermittently from approximately 2011 to March 2016. In-person communications occurred during breaks of several meetings of the technical team for the MYLF Conservation Strategy, and at several research and management meetings for MYLFs and the Yosemite toad. The NPS submitted a biological assessment (BA) to the FWS on February 24, 2016. The BA is included at: http://parkplanning.nps.gov/aquatics under "Supporting Documents."

The FWS responded to the NPS on May 25, 2016 with a Biological Opinion, including concurrence that the Restoration Plan as proposed is not likely to jeopardize the continued existence of the northern distinct population segment of the mountain yellow-legged frog, the Sierra Nevada yellow-legged frog, the Yosemite toad, the Little Kern golden trout, and the Sierra Nevada bighorn sheep (appendix L).

The Central Valley Regional Water Quality Control Board would determine whether to grant Waste Discharge Requirements and whether the proposed piscicide treatments are consistent with provisions for piscicide treatments in the Water Quality Control Plan for the Tulare Lake Basin (CRWQCB 2015A), and the Sacramento River Basin and San Joaquin Basin (CRWQCB 2015B). Prior to project implementation, SEKI would obtain the necessary permits. If piscicide applications are approved, a project-specific National Pollutant Discharge Elimination system (NPDES) permit for rotenone application would be obtained. The NPDES permit for the proposed treatments would contain receiving water limits applicable to rotenone projects as contained in the Tulare Basin, and Sacramento and San Joaquin Plans (CRWQCB 2015A, 2015B). It would also require water quality monitoring to verify compliance with receiving water limits within the project area and in downstream waters both during and after the treatment.

CDPR requires that pesticide applications be managed by trained and certified applicators. Though not a requirement for federal land managers, at least one member of the onsite piscicides application crew would be certified by CDPR 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).

If blasting of rock underlying a natural cascade to create a vertical fish barrier is selected for implementation, the parks would obtain a Section 401 Water Quality Certification from the Central Valley Regional Water Quality Control Board in order to be permitted to alter a stream course.

AGENCIES, ORGANIZATIONS, AND INDIVIDUALS CONSULTED

Agencies and organizations contacted to assist in identifying issues and provided with an opportunity to review or comment on this EIS include, but are not limited to, the following.

FEDERAL AGENCIES

U.S. Fish and Wildlife Service
U.S. Geological Survey, Biological Resources Division, Western Ecological Research Center
USDA Forest Service: Inyo, Sequoia, and Sierra National Forests

CONGRESSIONAL REPRESENTATIVES

U.S. Senator Barbara Boxer
U.S. Senator Dianne Feinstein
U.S. Congressman Tom McClintock, 4th Congressional District
U.S. Congressman Kevin McCarthy, 23rd Congressional District
California State Governor Jerry Brown
State Assembly Member Jim Patterson
State Senator Jean Fuller

STATE AND LOCAL AGENCIES

California Department of Fish and Wildlife, Regions 4 and 6, Fisheries Staff
California Department of Forestry
California Department of Forestry and Fire Protection
California State Historic Preservation Officer
Fresno County Board of Supervisors
San Francisco State University, Dr. Vance Vredenburg
Sierra Nevada Aquatic Research Laboratory (SNARL), Dr. Roland Knapp
Tulare County Board of Supervisors
Mr. Allen Ishida, District One Supervisor, Tulare County

AMERICAN INDIAN TRIBES, ORGANIZATIONS, AND INDIVIDUALS

Big Pine Paiute Tribe of the Owens Valley
Big Sandy Rancheria of Mono Indians
Bishop Indian Tribal Council
California Basketweavers Association
California Native American Heritage Commission
Cold Springs Rancheria of Mono Indians

Dunlap Band of Mono Indians
Fort Independence Paiute Indians
Kern Valley Indian Community
Native American Heritage Commission
North Fork Rancheria of Mono Indians
Paiute–Shoshone of Lone Pine
Santa Rosa Rancheria
Sierra Foothill Wuksachi Tribe
Sierra Nevada Native American Coalition
Table Mountain Rancheria
Tubatulabals of Kern Valley
Tule River Indian Reservation
Wukchumni Tribal Council
Wuksachi Indian Tribe

OTHER GROUPS AND ORGANIZATIONS

Backcountry Horsemen of California
California Preservation Foundation
Californians for Alternatives to Toxics
California Travel and Tourism Commission
Californians for Western Wilderness
California Trout
Center for Biological Diversity, California and Pacific Office
Fresno Audubon Society
Friends of the Earth
High Sierra Hiker's Association
Mineral King District Association
Mineral King Preservation Society
National Audubon Society; Tulare Audubon Society
National Parks and Conservation Association
The Nature Conservancy, California Field Office
Pacific Crest Trail Association
PEER
Save the Frogs
SCA Northwest Office
Sequoia Forest Alliance
Sequoia Natural History Association
Sequoia Riverlands Trust
Sequoia Parks Foundation
Sierra Club- National Headquarters; Tehipite Chapter; Kern-Kaweah Chapter; Sacramento Field Office
Sierra Forest Products
Tulare County Audubon Society
Western Environmental Law Center
Wilderness Land Trust
The Wilderness Society
Wilderness Watch
The Wildlife Society, San Joaquin Valley Chapter

AREA LIBRARIES

California State University: San Joaquin Sierra Unit
Fresno County Libraries
- Bear Mountain Branch Library
- Central Branch Library
- Sunnyside Branch Library
- Fowler Branch Library
- Kingsburg Branch Library
- Orange Cove Branch Library
- Parlier Branch Library
- Reedley Branch Library
- Sanger Branch Library
- Selma Branch Library

San Joaquin Valley College: Hanford Extension; Visalia Campus; Fresno Campus
Tulare County Law Library
Tulare County Libraries
- Exeter Branch
- Lindsay Branch
- Three Rivers Branch

MEDIA

Bakersfield Californian
Fresno Bee
Kaweah Commonwealth
Kern Valley Sun
Noticiero Semanal
Porterville Recorder
Reedley Exponent
Sanger Herald
San Francisco Chronicle

UNAFFILIATED INDIVIDUALS AND BUSINESSES

List is available upon request.

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Daniel Boiano has served as the SEKI aquatic ecologist since 2001, primarily implementing the Preliminary Restoration of MYLFs project. He earned a Master of Science from California State University – Humboldt, and a Bachelor of Science from the University of Connecticut. Overall, he has 20 years of experience working with management and research of high elevation aquatic ecosystems in California.

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Nancy Hendricks has served as the SEKI environmental protection specialist since 2009, and has 27 years of experience working for the National Park Service, including 25 years preparing environmental documents in accordance with the National Environmental Policy Act (NEPA). She earned a Bachelor of Science from Slippery Rock University of Pennsylvania.

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Isaac Chellman has served as the lead biological science technician in SEKI since 2012, as the crew leader and data manager for the Preliminary Restoration of MYLFs project. He earned a Master of Science and a Bachelor of Science from the University of Vermont. Overall, he has 15 years of experience working with management and research of aquatic ecosystems in California, Vermont, Guam, and Maryland.

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Erik Meyer served as an aquatic biologist and lead biological science technician in SEKI since 2008, primarily serving as the crew leader and data manager for the Preliminary Restoration of MYLFs project. He earned a Master of Science from California State University – Fresno, and a Bachelor of Science from The Ohio State University. Overall, he has 13 years of experience working with management and research of aquatic ecosystems in California and Oregon.

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Heather McKenny served as the aquatic ecologist for Yosemite National Park from 2008 to 2013, primarily managing high elevation aquatic ecosystems. She earned Master of Science and Bachelor of Science degrees from the University of Vermont. Overall, she has 7 years of experience working with management and research of aquatic ecosystems.

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AFS	American Fisheries Society
CDFW	California Department of Fish and Wildlife
CDPR	California Department of Pesticide Regulation
CFGC	California Fish and Game Commission
EPA	United States Environmental Protection Agency
FWS	United States Fish and Wildlife Service, U.S. Department of the Interior
IDFG	Idaho Department of Fish and Game
NPS	National Park Service, U.S. Department of the Interior
USDI	United States Department of the Interior
USFS	United States Forest Service, U.S. Department of Agriculture
USGS	United States Geological Survey, U.S. Department of the Interior

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As the nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering wise use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historic places, and providing for the enjoyment of life through outdoor recreation. The department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people. The department also promotes the goals of the Take Pride in America campaign by encouraging stewardship and citizen responsibility for the public lands and promoting citizen participation in their care. The department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

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