Preliminary Restoration of Mountain Yellow-legged Frogs

Environmental Assessment

Department of the Interior
National Park Service
Sequoia and Kings Canyon National Parks
Three Rivers, California 93271

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Summary

The mountain yellow-legged frog (*Rana muscosa*) once occurred throughout most of the high elevations of the Sierra Nevada. Within the last two decades, their populations have declined sharply. Scientists have investigated many different potential causes for the declines: acid deposition, UV-B radiation, diseases, contaminants and introduced predators. There is evidence that pesticide drift may be detrimental to their survival in some portions of their historic range, but introduced fish are the only proven cause for their decline. Fish and mountain yellow-legged frogs are largely incompatible. The fish fragment the frog populations and eliminate access to habitat, especially deep-water lakes that are important for surviving winter. Where fish are present, frogs are forced to use marginal habitat. The fragmentation hinders recolonization of lost populations. As more populations were lost without replacement, the losses became accentuated until the decline became a serious threat to their existence. We know from existing research that frogs can quickly repopulate lakes from which fish were removed when donor populations exist.

This document proposes some immediate actions to begin reversing the rapid losses of the species while a comprehensive program for their long-term management is being developed. This document proposes four alternatives. The "no action" alternative (Alternative 1), and three different action alternatives. Each of the action alternatives involve removing fish from seven to eleven different lakes using gill nets and from short adjacent stream segments using a combination of electrofishers and gill nets. All sites have high potential to benefit the frog population if fish are removed. The action alternatives differ primarily in the location of the lakes and the amount public accessibility to the lakes. Alternative 2 treats eleven lakes where there is little to virtually no public use. It is the preferred alternative because it is believed to be most feasible for success using gill nets to remove fish. Alternative 3 involves larger bodies of water and moderate public use. Alternative 4 involves a range of sites from very high public use to virtually no use. Maps are provided to show where each of the potential actions would occur.

Purpose and Need

Populations of mountain yellow-legged frogs (*Rana muscosa*) have declined precipitously from their historic abundance, and they are in danger of becoming extinct. Dorst and Fellers (1996) found that mountain yellow-legged frogs have disappeared from eighty-six percent of the sites where Grinell and Storer (1924) found them in 1915. Surveys by Bradford et al. (1994b) in Sequoia and Kings Canyon National Parks during 1989-1990 failed to find mountain yellow-legged frogs in forty-eight percent of the sites where they were found between 1955 through 1979. Within the Tablelands portion of the Kaweah drainage, mountain yellow-legged frogs declined ninety-six percent between the late 1970s and 1989 (Bradford et al. 1994b). Mountain yellow-legged frogs continue to occur in many areas of these parks, but most sites consist of small numbers of individuals that are vulnerable to extirpation (Fellers, pers. comm.; Knapp, pers. comm.).

Many different causes have been proposed for amphibian declines: Increases in UV-B radiation, acidic deposition, pesticides, introduced diseases, global warming, human disturbance, and introduced predators. To date, **the only proven cause of declines in mountain yellow-legged frogs is predation by introduced trout**. Introduced fish and mountain yellow-legged frogs are incompatible (Bradford 1989; Knapp and Matthews 2000; Vredenburg, pers. comm.). There is evidence that pesticide drift may be contributing significantly to the yellow-legged frog decline in the Kaweah River drainage (Fellers, pers. comm.) from which it is now believed to be extirpated except possibly at Pinto Lake. Other potential causes are being investigated, and some do contribute to local losses, but all known causes of decline are subordinate to predation by introduced fish. Some level of fish management is essential to restoring mountain yellow-legged frogs. In some areas of the Park, the staff may need to mitigate stressors additional to introduced fish, but the Park cannot wait for the definitive answer on all causes of decline to evaluate courses of action. The loss is significant already. We need to begin planning and implementing mitigation now for known threats to their survival.

If we fail to adequately conserve the species, they are likely to become a Federally listed endangered species. Without adequate mitigation of the causes of their decline, they could quickly become extinct.

This document identifies some alternatives for initiating action to conserve the species. It is of limited scope. It examines alternatives for immediate action to begin turning around the rapid decline of the species. Concurrently a programmatic environmental assessment is being prepared for long-term management of the species. It may not be available for several years because of existing gaps in information needed to adequately develop management alternatives and to evaluate those alternatives. This includes gaps in our understanding of threats to the species. Any preliminary restoration accomplished as a consequence of this document will also contribute to the final development of the programmatic environmental assessment. This document proposes some immediate actions supported by science. Selection of one of the action alternatives should prevent loss of some populations before they are extirpated, thus reducing the cost of the long-term program. A little restoration now should prevent the need for much more restoration later.

Background Information

Mountain Yellow-legged Frog Description:

Adults are a moderate-sized frog that varies from about one and a half to three inches (40-80 mm) head-body length. Dorsal color varies with varying mixes of olive-green, brown, and black. Color varies from mottled to spotted, and they may appear anywhere from drab to colorful. The ventral color is white to yellowish-beige. The underside of legs often contains a yellowish wash. Some red may be present.

Larvae (tadpoles) are very dark (nearly black) during their first year. Older larvae are slightly lighter and resemble large ripe olives with tails.

Mountain Yellow-legged Frog Biology:

Mountain yellow-legged frogs live high in the Sierra Nevada occupying lakes, ponds, tarns, wet meadows, and streams (Mullally and Cunningham 1956). Though they have been reported between 4,495 ft (1,370 m; Zweifel 1955) to over 11,975 ft (3,650 m; Mullally and Cunningham 1956), normally they are encountered in the upper half of that elevation range. There are also historic and some extant populations in the mountains of southern California (San Gabriel, San Bernardino, San Jacinto, and Mt. Palomar) living at lower elevations from 1,214 ft (370 m) to over 7,513 ft (2,290 m; Zweifel 1955; Jennings and Hays 1994).

Mountain yellow-legged frogs were once the common frog and large tadpole seen within their range. Mountain yellow-legged frogs are diurnal and once occurred in large numbers resulting in them being very conspicuous to early travelers. The frogs are an impressive sight when tens to hundreds of them leap into the water ahead of backcountry travelers. Though once common, they were rarely heard. The croaking frequently heard comes from a more diminutive frog found throughout their range, the Pacific treefrog (*Hyla regilla*). The adult frogs eat beetles, flies, ants, bees, wasps, bugs (Jennings and Hayes 1994), and treefrogs (Vredenburg, pers. comm.). Their predators include coyotes (*Canis latrans*), Brewer’s blackbirds (*Euphagus cyanocephalus*), western terrestrial garter snakes (*Thamnophis elegans*), and introduced fish (Jennings and Hayes 1994). There are observations of them being eaten by black bears and Clark's nutcrackers (Hayden, pers. comm.; Knapp, pers. comm.).

Breeding and egg laying is coincident with late snowmelt and usually occurs in late May, June, July, or early August, depending on conditions and elevation. Egg masses are normally laid in shallow water, especially in tiny springs and streams adjacent to lakes and ponds (Vredenburg, pers. comm.). Because the growing season is limited to summer and early fall, it can take up to three summers (possibly four) for the larvae (tadpoles) to metamorphose into adults. During the summer, larvae congregate in shallow waters where the warmer temperatures facilitate their development. Sometimes hundreds of larvae can be seen within a few square feet of warm shallow water (Bradford 1984).

Both adults and larvae must be able to survive the winter. Larvae can survive the loss of oxygen when shallow lakes freeze to the bottom, but adults are much more susceptible to winter kill (Bradford 1983). Adults must have deep lakes or other refugia from anoxic conditions caused by winter ice.

Significance of Mountain Yellow-legged Frogs:

Mountain yellow-legged frogs are a subalpine/alpine predator of both aquatic and terrestrial invertebrates, as well as some vertebrates like the Pacific treefrog (*Hyla regilla*; Vredenburg, pers. comm.). In turn, they are a major source of food to larger alpine predators like the western terrestrial garter snake (*Thamnophis elegans*). The loss of mountain yellow-legged frogs is likely to have a measurable impact on the natural functioning of the lakes and streams within their historic range. Their loss could change the abundance of some other species with which they interact.

Impacts from their loss are not just ecological. It will effect the experience of backcountry users. Walking upon a lake shore and witnessing tens to hundreds of frogs jumping into the water is a stimulating experience. The same can be said for seeing the water explode into tiny droplets as hundreds of tadpoles basking in shallow water are startled by a hiker. Watching the large tadpoles gracefully swimming through the clear water or watching adult frogs floating lazily on the surface while awaiting prey can provide hours of entertainment for the wilderness traveler. The experience one finds in waters that have lost their frogs is far more sterile and far less natural.

Amphibian Declines, the Phenomena

For over a decade, scientists have been noting the dramatic world-wide decline of amphibians (Blaunstein and Wake 1990; Wake 1991). Many different theories have been developed to explain the losses and in many cases there was local data to support one or more of the hypotheses. In many cases, scientists have few clues. The list of possible causes omits few options: increased UV-B radiation as a consequence of the thinning stratospheric ozone layer; pollution; acid deposition; pesticides; introduced diseases; introduced predators; global climate change; habitat destruction; misinterpretation of natural stochastic events; and various combinations of the above postulates. Occasionally one sees articles in the popular media that compare amphibians to the coal minors canary and warn that amphibian losses are an early warning for ourselves.

In addition to declines, there is another phenomenon that concerns scientists. In some areas, frogs are developing deformities that range from missing to extra legs. This has been attributed to some of the same processes believed to be effecting declines (e.g. UV-B radiation, Ankley 1996-1997), but natural causes like trematodes have also been identified (Sessions 1996-1997). Deformities are not an issue in the Sierra Nevada (Fellers, pers. comm.).

As stated above, an introduced predator (trout) is the one definite cause contributing to the declines of mountain yellow-legged frogs. Introduced predators are not a problem unique to the mountain yellow-legged frog. Declines in a variety of western of frogs have been attributed, in part, to the introduction of predators like bullfrogs, bass and sunfish, catfish, mosquito fish, and red swamp crawfish (Corn 1994; Cowles and Bogert 1936; Dumas 1966; Hammerson 1982; Hayes and Jennings 1986; Jennings and Hayes 1994; and Moyle 1973).

Introduced diseases have been blamed for the destruction of many amphibian populations. Redleg disease contributed to losses of several species of toads and larval tiger salamanders in the western United States (Carey 1993; Collins et al. 1988; Kagarise et al. 1993; Worthylake and Hovingh 1989). Both Bradford (1991) and Knapp (pers. comm.) reported it to cause losses of mountain yellow-legged frogs. They reported it as localized cases and not likely to cause widespread declines. Redleg disease is often a consequence of immune systems being weakened by stress (Corn 1994). The fungus that causes Redleg disease, *Saprolegnia*, is frequently found in hatcheries, and its spread is another consequence of planting trout.

Recently, a newly discovered form of Chytrid fungus that has shown up on several different continents has been found to have devastating effects on frog populations (Kaiser 1998). Normally these fungi effect insects and plants, but this form kills frogs.

One source of environmental stress is acidic deposition. Tome and Pough (1982) looked at fourteen species of amphibians, and found that when pH drops to four or less, mortality during embryonic development is over fifty percent. This increased to eighty-five percent with pH between 3.7 to 3.9. Acidic deposition has been suspect as a contributing cause to amphibian declines in a variety of places (Blaustein and Wake 1990; Carey 1993; Harte and Hoffman 1989; Wyman 1990), and episodic acidification does occur in these parks, though as a rare event in basins with low acid neutralizing capacity (Stoddard 1995). Bradford et al. (1992) found that *Rana muscosa* embryos and hatchlings were not sensitive to pH values recorded in high-elevation Sierra Nevada lakes. From an analysis of pH at 235 potential breeding sites, Bradford et al. (1994a) concluded that acidic deposition is not a likely cause of amphibian declines in the Sierra Nevada. However, Bradford et al. (1998) reported that mountain yellow-legged frog tadpoles were absent in acidic lakes (pH <6) in the vicinity of Mt. Pinchot (Bradford et al. 1998). When nine lakes and ponds in the Middle Fork Kaweah drainage were surveyed in 1993, eight of nine field pH measurements were below pH 6 (unpublished data). The one high pH of 8.1 was from a pond in marble, a rock that neutralizes acidity. Mountain yellow-legged frogs are believed extirpated from the Kaweah drainage except possibly in Pinto Lake.

There are other pollutants in the air that may be more serious. The southern and central Sierra Nevada are downwind of one of the most intensely cultivated areas on earth (Cory et al. 1970). Fresno and Tulare Counties used over fifty-three million pounds of pesticide active ingredients in 1997 (Department of Pesticide Regulation 1999). Combined with Kings and Kern Counties, over eighty-five million pounds (Department of Pesticide Regulation 1999) of pesticide active ingredient are used in agricultural areas upwind of the southern Sierra Nevada. Measurable quantities of organophosphate pesticides were in the Sierra Nevada at 6,300 ft with increasing concentrations at lower elevations (Zabik and Seiber 1993). Datta et al. (1998) found PCBs and DDE in trout in the Kaweah drainage. Pacific treefrog (*Hyla regilla*) tadpoles contained PCBs, chloropyrifos, chlorthalonil, and a chloronitrile fungicide. In the late 1960s, Cory et al. (1970) found DDE residues in mountain yellow-legged frogs with the heaviest concentrations being in the southern and central Sierra Nevada.

Other air pollutants are also cause for concern. Jennings (1996) reported a conversation with T. Cahill stating that studies by the Crocker Nuclear Laboratory have noticed that the pattern of recent frog extinctions in the southern Sierra Nevada corresponds to the patterns of highest concentrations of exhaust pollutants from automobiles. Nitrates and nitrites are associated with automobile pollution. Marco et al. (1999) found some amphibian larvae sensitive to elevated nitrite and nitrate concentrations. The effects increased with both concentration and time.

Air pollution is also implicated in indirect impacts to amphibians. Global warming is a consequence of anthropogenic generation of greenhouse gases like methane and carbon dioxide. Recently, Pounds et al. (1999) demonstrated the loss golden toads and associated species in Costa Rica due to global warming. As the climate warmed, these mountaintop species were stranded as their climatic requirements moved above the mountaintop.

Another indirect effect of air pollution is the thinning of stratospheric ozone as a consequence of chloroflorocarbons resulting in increased ultraviolet radiation, especially the UV-B region of the spectrum. Blaustein et al. (1994, 1995, 1997) attributed the decline of several amphibians to UV-B radiation. However, other investigators have not been able to replicate his experimental results (Corn 1998; Grant and Licht 1995; Ovaska et al. 1997; Vredenburg, pers. comm.). Exposing embryonic stages to ultraviolet radiation does reduce survival for some species (Blaustein et al. 1994, 1995, 1997; Grant and Licht 1995; Hayes et al. 1996; Worrest and Kimeldorf 1975, 1976) and can cause developmental malformations (e.g. extra or missing limbs) in a laboratory situation (Ankley et al. 1998). What can be done in a laboratory does not necessarily resemble what happens in nature. In a natural environment, larvae have the ability to avoid UV-B radiation by shielding themselves under vegetation, in rock crevices, and under mud and detritus. There is no published evidence, to date, that UV-B radiation has caused declines of mountain yellow-legged frogs, but that does not mean that they are not potentially sensitive to changes in ambient levels.

Direct habitat destruction is one of the most visible causes of amphibian attrition. Some amphibian losses can be attributed to the conversion of wetlands to urban or agricultural use (Corn 1994). Other alterations are subtler. Jennings (1996) noted that: "aquatic habitats of the Sierra Nevada have been greatly altered through dams, diversions, channelizations, siltation, livestock grazing, timber harvest, placer mining, and many other factors". This would appear to be an unlikely cause that is unlikely to be a factor in the loss of mountain yellow-legged frogs because they occupy high-elevations sites, most of which are far removed from human engineering projects. Many of the historic populations occurred in remote basins that infrequently see human use. Most populations are within federal wilderness or in national parks where they and their habitat are fully protected.

When thinking about amphibian declines, one must also consider that not all losses are necessarily the result of human intervention. Fluctuations have been reported in amphibian populations (Pechmann et al. 1991, Pechmann and Wilbur 1994). It is important to be able to distinguish between natural events and loses attributable to human impacts.

It is also important to realize that in many cases there may be a combination of causes contributing to amphibian losses. As stated above, we know that predation by introduced fish is a primary cause of declines of mountain yellow-legged frogs. However, it is likely that other causes, and possible some that we never considered, may also be contributing to the decline. We are especially concerned about atmospheric transport of toxic compounds.

Why Now?

If fish planting has been going on since the mid to late 1800s, why didn't the dramatic declines begin to occur until the last two decades? We believe the answer lies in the cumulative effects of fragmentation. Within their habitat, not all water carries equal value: some ponds are better homes or serve certain functions better than others. Ponds that may be good for breeding may not be the best sites for over-wintering. Matthews and Pope (1999) documented seasonal movement between ponds. In addition to seasonal movements, some sites may produce excess frogs; others maintain their populations by immigration from more productive sites. Before fish were introduced, there was connectivity, thus potential for effective movement, between the ponds. Frogs could freely move between ponds to achieve their seasonal needs, and ponds that lost frogs could be recolonized from nearby locations.

Because trout and mountain yellow-legged frogs are largely mutually exclusive (Bradford et al. 1994, Knapp 1996), the introduction of trout fragmented the historic connectivity. Gauntlets of predatory fish impeded seasonal movements. Fish populated most deep-water over-wintering sites. Frog populations became fragmented and isolated. Then, if the population of a pond was wiped out by a catastrophic event like drought, disease, or winter-kill, often there were no adjacent source sites for recolonization. The addition of environmental stressors like air pollution and introduced diseases may have increased the frequency of local catastrophic events. Not only do populations become more isolated with the loss of connectivity, but with isolation, there is likely to be increased inbreeding and possible loss of genetic viability. Furthermore, amphibian populations have been shown to have natural fluctuations (Pechmann et al. 1991). Without connectivity, the means to recover from an inherent drop in numbers would be more limited. What might have been a downward fluctuation two-hundred years ago could easily turn into another local extirpation without connectivity today. As isolated populations disappeared, the distance between potential sources increased. As isolation and environmental stressors increased, it is likely that the rate of frog declines increased.

Origin of Alpine Fish

Fish are not native to most of the upper elevations of the Sierra Nevada. Pleistocene glaciation and steep topography created barriers to fish moving upstream (Christensen 1977, Moyle et al. 1996). West of the Sierra Crest, most native fish (primarily coastal rainbow trout) occurred below 4,900 ft (1,500 m), but may have reached 7,200 ft (2,200 m) in the Kings watershed (Moyle et al. 1996). South of the glaciation, golden trout ranged upwards to 9,800 ft (3,000 m; Moyle 1996). In the eastern watersheds of the Sierra Nevada, Lahontan cutthroat trout also ranged upwards to 9,800 ft (3,000 m; Moyle 1966). When Caucasians first came to the high country, most of the waters were naturally barren of fish.

Planting fish in the Sierra Nevada began in the 1850s and became widespread in the 1870s (Christensen 1977). Initially planting was done by stock users, anglers, and anyone else that wanted to move fish into areas barren of fish. By 1912, the Department of Fish and Game had become involved in planting fish. In general, brown trout (Locch Laven) were planted at the lower elevations, rainbow trout at the mid elevations, and golden trout in the high Sierra. Later, eastern brook trout were added to the species planted in the mid-elevations and cutthroat trout to the high elevations (Department of the Interior 1989).

In the early days, fish planting was done primarily by pack stock, but aircraft began to be used in 1940 (Department of the Interior 1989). This increased the efficiency of the fish planting effort and increased the number of places where fish could be planted. Fish planting was not done in Sequoia and Kings Canyon National Parks after 1988.

Stability of Fish Populations:

Most of the lakes have rather low productivity because they are primarily in granitic basins and at very high elevations. There was an initial abundance of food causing the fish to do well initially, but the productivity could not sustain them. Fish became stunted or their populations declined to where they were in equilibrium with the lake (Pister 1977). Lakes planted with eastern brook trout are particularly prone to becoming stunted. Other species generally sustain themselves at a level that maintains healthy-looking fish. A survey of 137 lakes in Sequoia and Kings Canyon National Parks showed that sixty-one percent were self-sustaining, ten percent were probably self-sustaining, twelve percent showed little evidence of fish reproduction, four percent were not producing any new fish, and thirteen percent were barren of fish (Zardus et al. 1977). Knapp and Matthews (2000) found fish at twenty percent of the 1,059 lakes and ponds surveyed in northeastern Kings Canyon National Park. These numbers are not that different since Zardus et al. (1977) excluded ponds.

One consequence of the general low productivity of Sierran waters was an effort to enhance trout food. In 1919, the Department of Fish Culture introduced an amphipod

(*Hyalella azteca*) and an alga (*Nitella* sp) to Rae Lakes to enhance the fish food supply (Department of the Interior 1989).

Ecological Impacts of Introduced Trout:

As discussed above, introduced trout are a known cause for the decline of mountain yellow-legged frogs (Bradford et al. 1993; Knapp 1996; Vredenburg pers. comm.). Their introduction has also impacted other organisms. In the northern Sierra Nevada, the long-toed salamander appears to be found primarily in fishless lakes (Bradford and Gordon 1992).

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

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

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

Applicable Law and NPS Policy:

The law establishing the National Park Service (16 U.S.C. l, 2, 3, and 4), popularly referred to as the NPS Organic Act, defines our purpose as: "to conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations." How the National Park Service implements its mission is described in its Management Policies. Applicable excerpts from the NPS Management Policies (National Park Service 2001) state that:

- “Natural resources will be managed to preserve fundamental physical and biological processes, as well as for individual species, features, and plant and animal communities.”
- “The National Park Service will maintain as parts of the natural ecosystems of parks all native plants and animals. . . . The Service will achieve this maintenance 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;
  - Restoring native plant and animal populations in parks when they have been extirpated by past human-caused actions; and
  - Minimizing human impacts on native plants, animals, populations, communities, and ecosystems, and the processes that sustain them."
- “The Service will strive to protect the full range of genetic types (genotypes) of native plant and animal populations in the parks by perpetuating natural evolutionary processes and minimizing human interference with evolving genetic diversity. The restoration of native plants and animals will be accomplished using organisms taken from populations as closely related genetically and ecologically as possible to the park populations, preferably from similar habitats in adjacent or local areas.”
- “The Service will strive to restore extirpated native plant and animal species to parks wherever all the following criteria are met:
  - Adequate habitat . . . exists or can reasonably be restored . . .
  - The species does not . . . pose a serious threat to the safety of people in parks, park resources, or persons or property outside park boundaries;
  - The genetic type used in restoration most nearly approximates the extirpated genetic type; and
  - 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.”
- “Exotic species will not be allowed to displace native species if displacement can be prevented."
- "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; . . ."
- “The Service will seek to perpetuate the best possible air quality in parks . . . Vegetation, visibility, water quality, wildlife . . . and most other elements of a park environment are sensitive to air pollution and are referred to as ”air quality related values.” The Service will assume an aggressive role in promoting and pursuing measures to safeguard these values from the adverse impacts of air pollution."

Alternatives

Alternative 1, No Action:

Under this alternative, no action would be taken to prevent continued declines of mountain yellow-legged frogs, nor would there be any effort to restore frogs to areas from which they were extirpated.

The Park would continue to seek research into factors influencing the long-term survival of mountain yellow-legged frogs and documenting the current status of the species.

Alternative 2, Restore Select High-benefit Low-use Lakes (Preferred Alternative):

Under this alternative, introduced fish would be removed from select lakes (Fig. 1, 2, 3 & 4) and adjacent stream segments at sites with little to no visitation. Stream removals would extend to the nearest natural barrier that would prevent fish from returning from downsteam locations. Natural barriers include high waterfalls and steep cascades without pools. Fish would be removed from lakes using gill nets and from stream segments using a combination of repeated electrofishing[1] and gill nets. Though labor-intensive, gill nets can effectively remove fish from some lakes (Knapp and Matthews 1998; Milliron, pers. comm.; and Vredenberg, pers. comm.). The selected lakes are located at sites believed to have a high potential for removing fish using gill nets and high potential for recolonization by frogs once the fish are removed. The selected lakes have good potential frog habitat and good proximity of extant frog populations when the areas were last surveyed in 1997 or 2000.

If restoration proceeds ahead of schedule, additional sites would be selected from alternatives 3 and 4.

Alternative 3, Restore Select High-benefit Moderate-use Lakes:

Under this alternative, introduced fish would be removed from select lakes (Fig. 1, 4 & 5) and adjacent stream segments at sites with little to moderate visitation. Other information is the same as Alternative 2.

If restoration proceeds ahead of schedule, additional sites would be selected from alternatives 2 and 4.

Alternative 4, Restore Select High-benefit Mix of High-use and Obscure Lakes:

Under this alternative, introduced fish would be removed from select lakes (Fig. 1, 6, 7 & 8) and adjacent stream segments at sites with a range of no to very high visitation. Other information is the same as Alternative 2.

If restoration proceeds ahead of schedule, additional sites would be selected from alternatives 2 and 3.

[1] An electrofisher is a device that stuns fish so that they cam be captured.

Figure 1. Restoration Sites for Mountain Yellow-legged Frogs at Sequoia and Kings Canyon National Parks

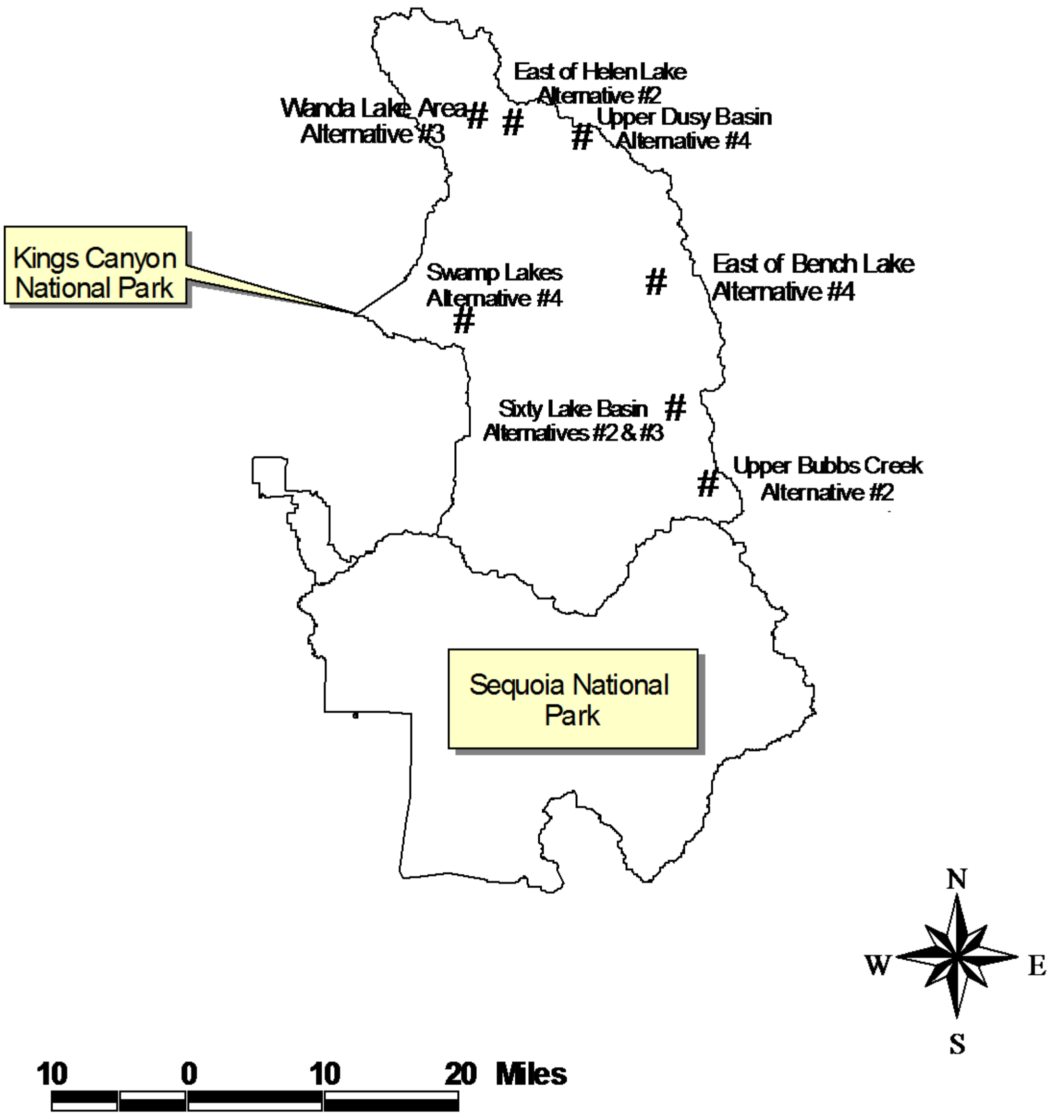


Figure 2. Restoration Sites East of Helen Lake

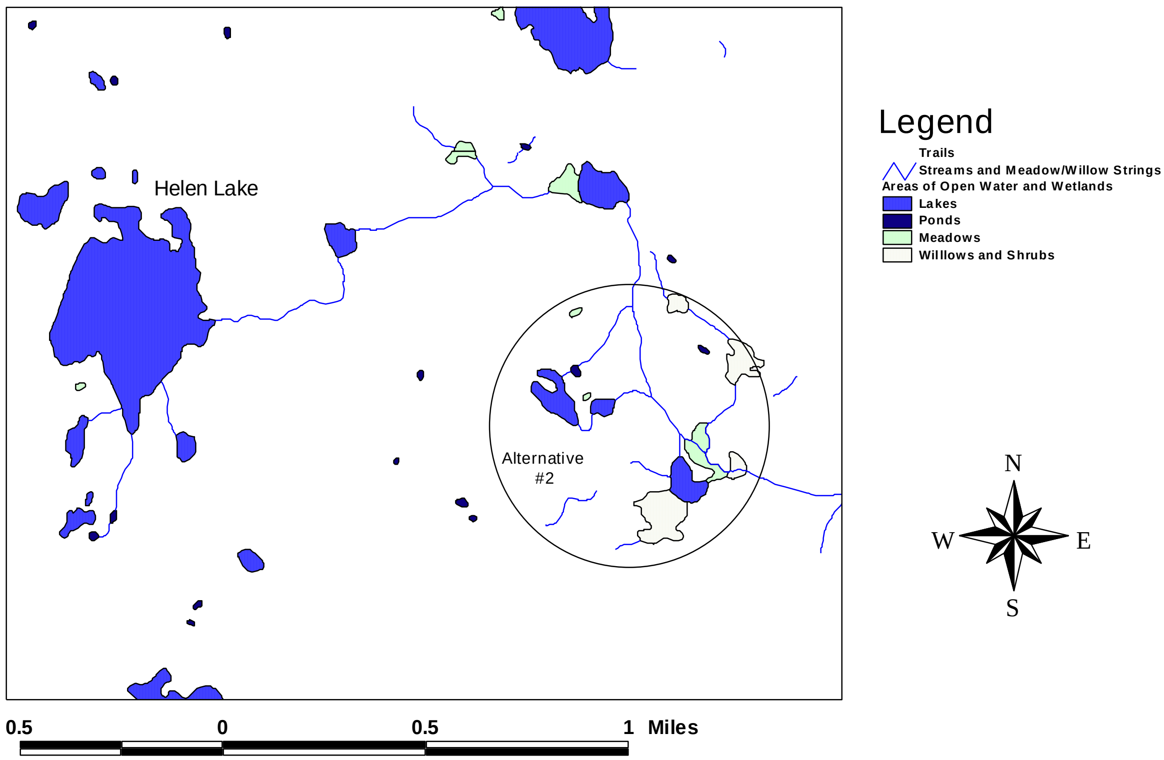


Figure 3. Restoration Sites in Upper Bubbs Creek

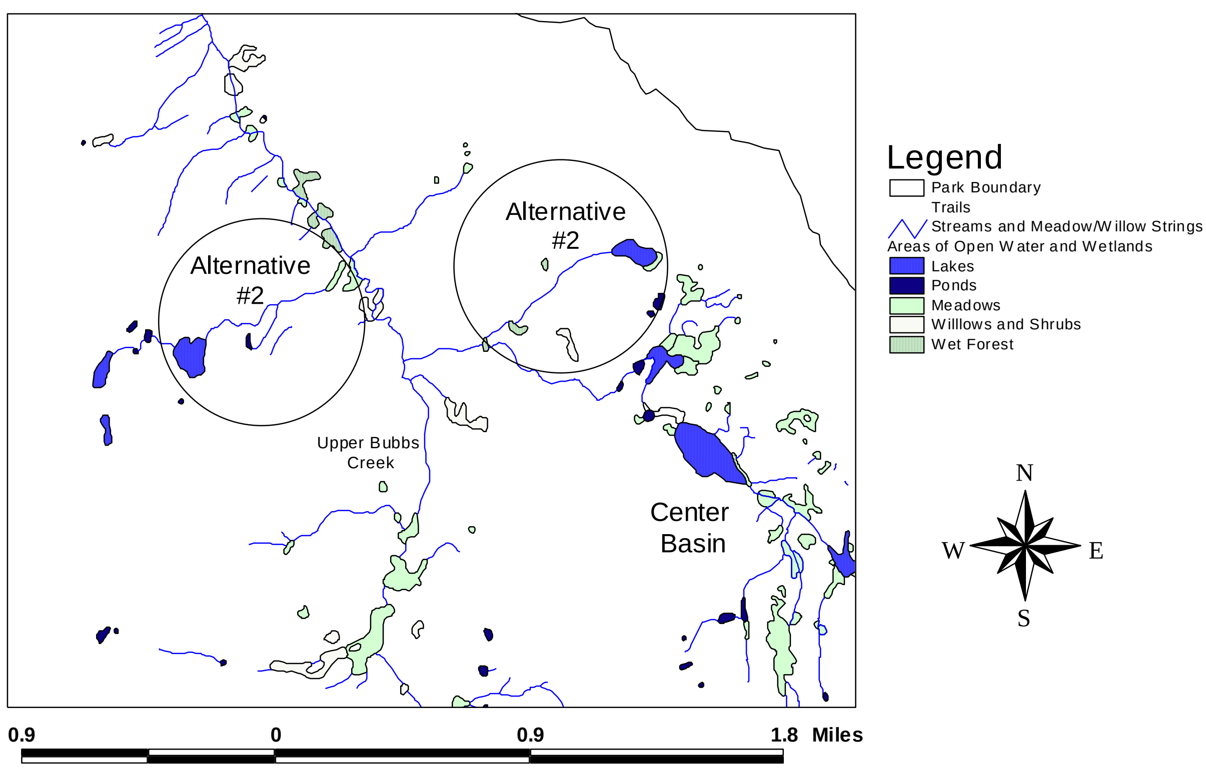


Figure 4. Restoration Sites in Sixty Lake Basin

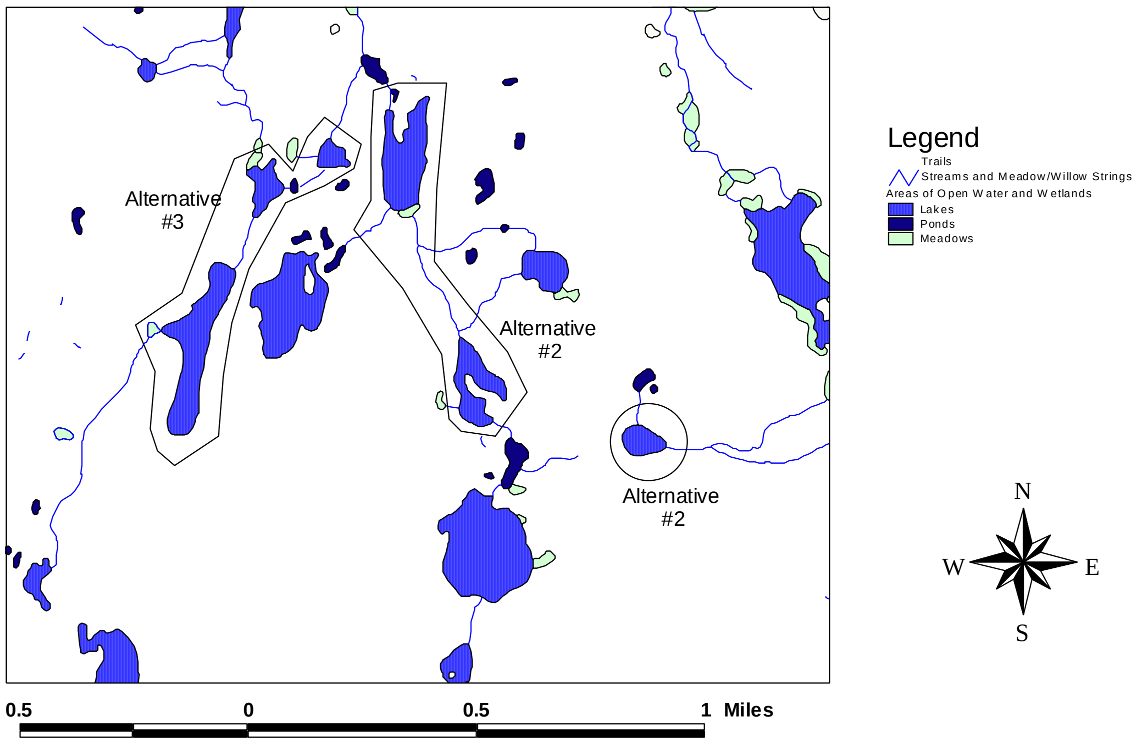


Figure 5. Restoration Sites in Wanda Lake Area

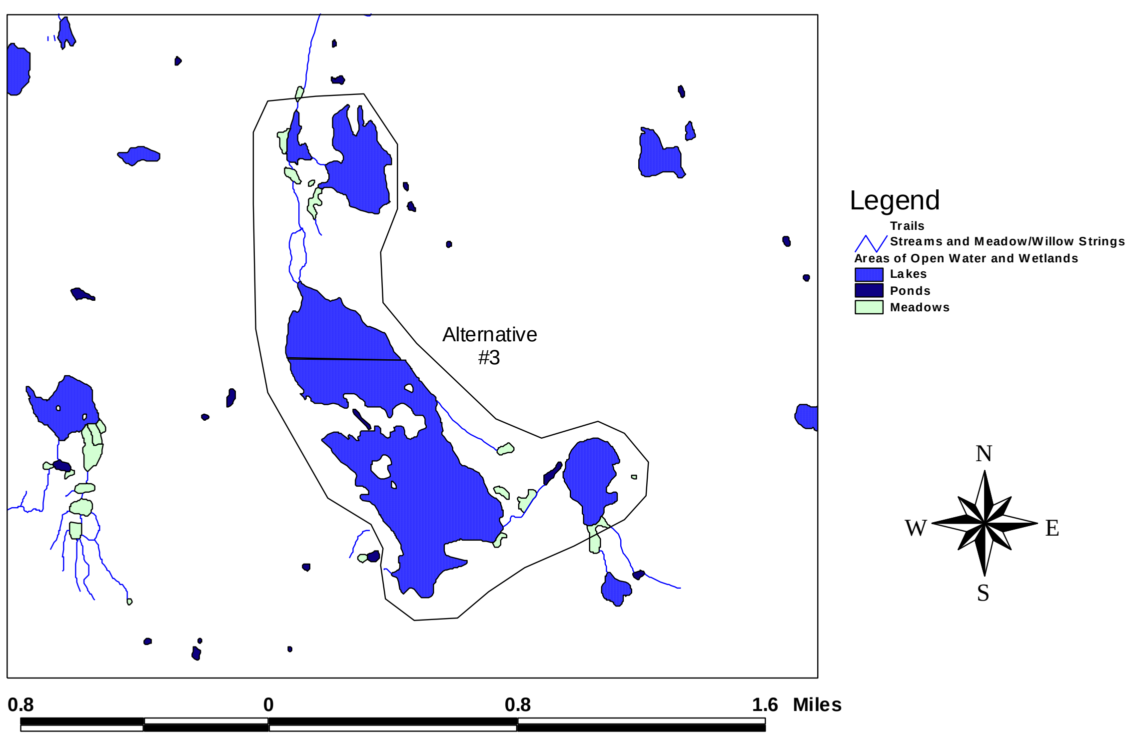


Figure 6. Restoration Sites in Upper Dusy Basin

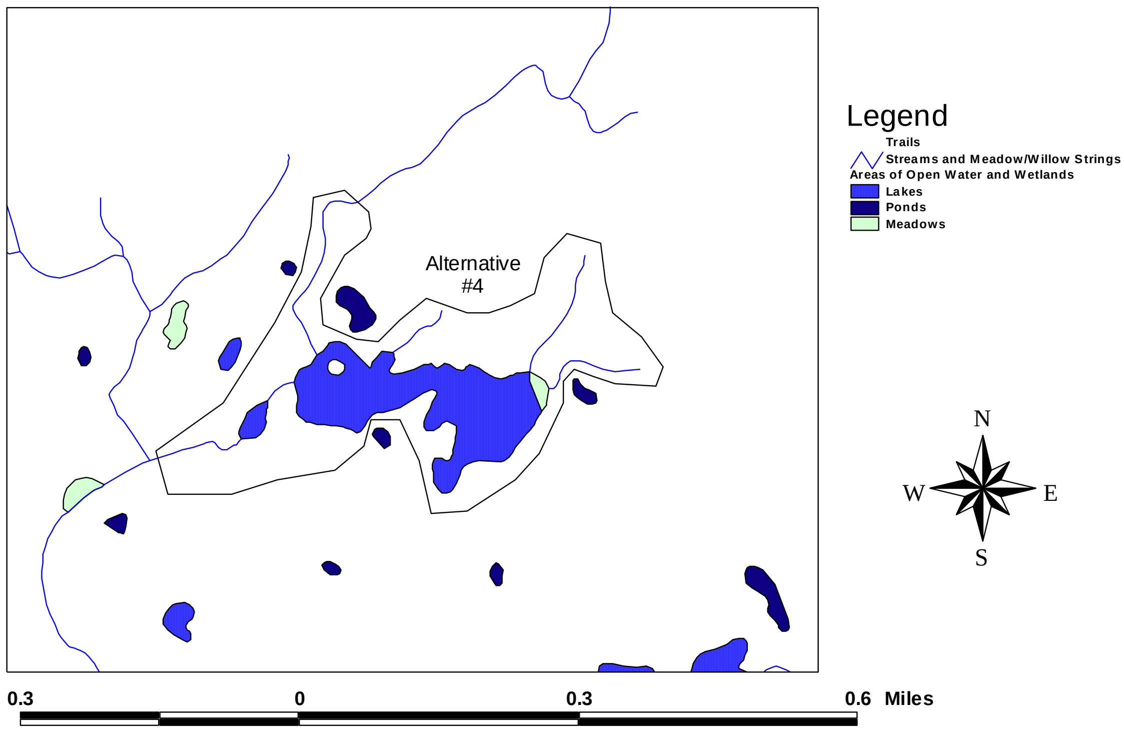


Figure 7. Restoration Sites East of Bench Lake

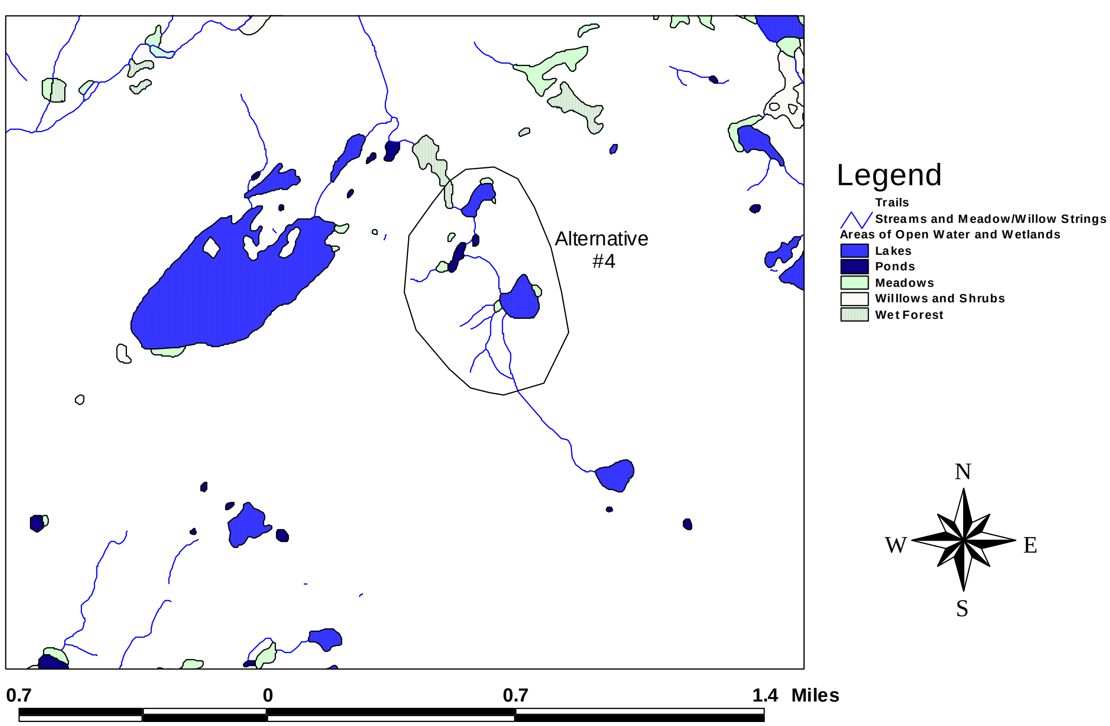
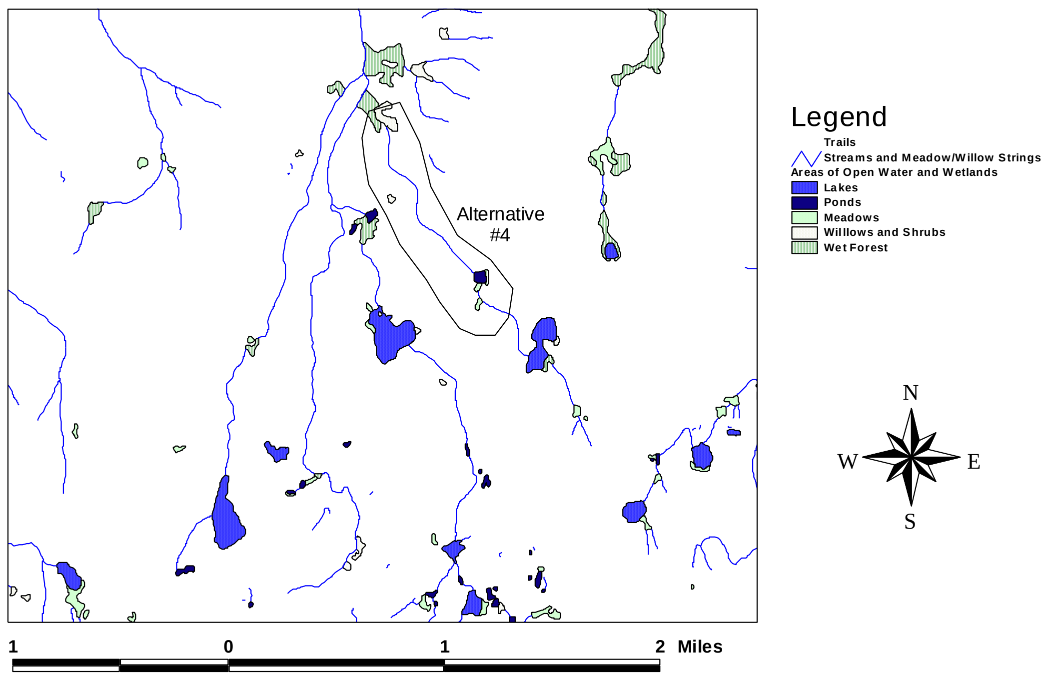


Figure 8. Restoration Site at Swamp Lakes



Affected Environment

Geographic Extent:

The geographic extent of areas potentially affected by the restoration varies with the alternatives (Table 1). Table 1 describes the number of lakes and ponds, the acreage of lakes and ponds, and the total maximum length of stream habitat that could be affected by each of the alternatives.

Table 1. Comparison of number of lakes and ponds, total surface area, and stream miles associated with each alternative.

Alternatives	General Area	Number of Lakes/ponds	Acres to Treat	Stream Miles to Treat
1	None	0	0	0
2	East of Helen Lake, Upper Bubbs Creek, SE Sixty Lake Basin	11	45	<2.3
3	Wanda Lake Vicinity, SW Sixty Lake Basin	9	216	<0.8
4	Upper Dusy Basin, East of Bench Lake, Eastern Swamp Lake Basin	7	24	<1.8

Natural Resources:

The proposed project occurs within the elevation range above 8,000 ft and below 11,600 ft. The proposed treatment sites occur from the mid-subalpine to the lower-alpine zones of the Park.

Above 7,400 ft is the beginning of elevations that are currently most frequented by the mountain yellow-legged frogs. Moving up into the lower reaches of the subalpine zone, Jeffrey pine, red fir, western white pine, and lodgepole pine become increasingly characteristic of the vegetation up to about 10,000 ft where the dominant forest becomes stands of foxtail pine, white-bark pine, and lodgepole pine. Between about 8,000 ft and 11,500 ft, the landscape varies from subalpine forest to open alpine fell-field, prairie, meadow, and sparse rocky areas. Lodgepole pine favors the more moist sites, and often occurs in the vicinity of mountain yellow-legged frogs. Above 11,500 ft, the vegetation is primarily open alpine country. From about 9,000 ft to 12,000 ft, lakes, ponds, streams, and wet meadows are common. Mountain yellow-legged frogs historically used all but the highest of these sites.

Other wildlife that are sympatric with the mountain yellow-legged frogs include a mix of alpine/subalpine species with those that are also common to much lower elevations. Examples of alpine/subalpine species include Clark's nutcracker (*Nucifraga columbiana*), gray-crowned rosy finch (*Leucosticte tephrocotis*), pika (*Ochotona princeps*), alpine chipmunk (*Tamias alpinus*), yellow-bellied marmot (*Marmota flaviventris*), and Sierra Nevada bighorn sheep (*Ovis canadensis*). Species that are more ubiquitous include the mule deer (*Odocoileus hemionus*), coyote (*Canis latrans*), deer mouse (*Peromyscus maniculatus*), dark-eyed junco (*Junco hyemalls*), common raven (*Corvus corax*), and the pacific treefrog (*Hyla regilla*).

The majority of the range of the mountain yellow-legged frog is in areas dominated by granitic rock. There are some areas of metamorphic rock like schist and marble. These areas also sustain frog populations. Soils in most of thess areas are shallow to non-existent and poorly developed.

Most of the alpine/subalpine waters could be described as cold, clear, and very low ionic potential. Water temperatures range from freezing up to about 15^{o}C, though very shallow water with good solar exposure may go up to around 20^{o}C. Water turbidity for lakes and streams is usually below 0.2 NTU, but this may double or triple in ponds and wet meadows. In granitic areas, conductivities are generally below 10 :s cm^{-1} in lakes and ponds but may exceed 40 :s cm^{-1} in streams, meadows, or metamorphic areas. Lakes and streams are typically saturated with oxygen (>8 mg l^{-1}), but wet meadows sometimes have less oxygen, probably due to the organic soils and decomposing vegetation. In general, the pH of alpine waters is slightly acidic, but varies from slightly alkaline to acidic. The water is poorly buffered and ANC (acid neutralizing capacity) is usually below 0.1 meq l^{-1}.

Cultural Resources:

Human use of the Sierra Nevada goes back several thousand years. Native Americans used the high country during the summer and crossed the high passes to implement trade between cultures living east and west of the Sierra crest. Archeological sites within the high country represent seasonal camps and other use. Artifacts include obsidian flakes, projectile points, pottery fragments, beads, stone utensils, bone tools, and woven artifacts.

From about 1850 to the creation of Sequoia National Park in 1890, the high country was used extensively by Caucasians. Ranchers used the high country to graze cattle and sheep. Miners looked for mineral wealth in the high country. There are about a dozen mine shafts (primarily in the Mineral King area) and numerous prospects. Trappers worked the area for the fur trade, and several cabins still exist in the conifer belt that were built and used by trappers. It was during this period that many of our high lakes were planted with fish.

The largest anthropogenic structures in the high country are four dams built around the turn of the century. They were constructed to facilitate electrical power generation downstream.

Most of the human structures in the high country relate to contemporary management by the National Park Service. These include trails, trail signs, a few ranger stations, and a few historic buildings like the Smithsonian shelter on top of Mt. Whitney.

Social Values:

Most of the area formerly inhabited by mountain yellow-legged frogs is designated wilderness. This legal distinction provides further need for the land to be "protected and managed so as to preserve its natural conditions" such that "the earth and its community of life are untrammeled by man" (16 USC 1131 et seq.). For the visitor, wilderness "has outstanding opportunities for solitude or a primitive and unconfined type of recreation" (16 USC 1131 et seq.). While some of the trail segments may seem incredibly busy during the peak of backcountry use in late July and August, solitude abounds during most of the year. Even during the busy summer, there are numerous places where contact with other people can be virtually avoided.

People use the high country in many different ways. The majority of the backcountry users are backpackers, but many people use pack stock (horses, mules, burros, or llamas) to enjoy the high Sierra. Party sizes vary from one or two people to large groups. Visitors come to the Parks' high country for many different reasons. Some people come to fish the high lakes and streams. Others only hike, relax, and enjoy the beauty. Some want to see and study the natural environment. Most visitors only stay for a few days, others stay for weeks at a time. The one thing that nearly all have in common is that they came to recreate.

Impacts

Alternative 1, No Action:

Impacts to the Natural Environment:

Wetlands and Vegetation

The parks high mountain lakes are often ringed by social trails caused by people walking around the edge of the lakes. These trails often reduce the vegetative cover to bare soil. Angling for introduced fish is one of the activities that contributes to the formation and perpetuation of these trails, but there is no data to distinguish how much of the vegetation loss is caused by angling as opposed to people walking around the lake for other purposes. This alternative perpetuates all existing shoreline traffic and associated social trail development. Because most of the sites proposed for treatment in the alternatives that follow are infrequently visited, the extent of continued vegetation damage would be minimal within most of the potential project area.

Riparian vegetation along streams with introduced fish generally does not show evidence of social trails. However, occasionally angling does result in hooks, lures, and fishing line becoming permanently entangled on streamside vegetation.

Wildlife, Vertebrates

Mountain yellow-legged frogs (*Rana muscosa*) would continue to decline. There is a chance of them continuing to survive locally in the few aquatic systems that are fishless and consist of good habitat. However, such sites would be very isolated and may not be large enough to sustain long-term viability. In a best-case scenario, mountain yellow-legged frogs are likely to be extirpated from most of their range. In a worst-case scenario, they could become extinct. In turn, all species that either preyed upon the frogs for food or which conversely were eaten by the frogs would be impacted by the loss. Frog predators may decline from some areas formerly inhabited by mountain yellow-legged frogs.

Wildlife, Invertebrates

Invertebrate populations are likely to be altered in several different ways. As the mountain yellow-legged frogs continue to decline and disappear, the high Sierra will loose a large predator that formerly was abundant there. The insects and other prey on which the frogs once fed should become more abundant. This in tern may benefit other insectivorus predators, like flycatchers.

Self-sustaining populations of introduced fish would continue to remove large invertebrates permanently altering the natural ecology of those lakes. Large zooplankton like *Hesperodiaptomus* sp. and *Daphnia middendorffiana* would continue to be missing from the zooplankton communities. Knapp et al. (In press) found that lakes and ponds with fish contained more mosquito larvae than sites without fish. They speculate this is probably because fish eat the large predaceous insects that are the primary predators on the mosquito larvae. Allowing the introduced fish to persist could be contributing to more mosquitoes. The only lakes that would return to a more natural condition are those where fish populations are not self-sustaining. These may be as few as seventeen to twenty-nine percent (Zardus, et al. 1977).

Threatened, Endangered, or Sensitive Species

As stated above, mountain yellow-legged frogs (*Rana muscosa*) would continue to decline. No other listed or sensitive species should be effected by this alternative. However, it is likely that some of the rare subalpine carnivores like red fox (*Vulpes vulpes*) and wolverine (*Gulo gulo*) may feed on mountain yellow-legged frogs where frog populations still exist. If so, the loss of frogs could decrease food availability for rare carnivores.

Water

The water column would probably change little under this alternative. As frogs would continue to decline, so would their larvae. The larvae are detritivores, but they do also consume algae and meat (Vredenburg, pers. comm.). The loss of the frogs from isolated fishless lakes could result in a decrease in nutrient input and an increase in algae growth. This could result in alpine waters becoming even more oligotrophic. Where fish are present, the water column is expected to remain the same.

Air

Air quality should remain unchanged by this alternative. We would continue to manage air quality in accordance with the Clean Air Act (42 USC 7401 et seq.) and National Park Service policy. We would continue to encourage research that looks for connections between potential pollutants and frog populations that were lost in virtually fishless areas. We would continue to inform the public about pollution concerns. We would continue to use our best available information to influence decisions that effect the Parks' air quality.

Geologic Resources/Substrate

The continued presence of fish is probably causing a change in the depositional record of lakes and ponds as sediments accumulate bones and exoskeletons from an unnatural assemblage of biota. With introduced fish causing changes in the composition of zooplankton, it is likely that there are changes in the composition of the phytoplankton which constitute part of their diet. These changes could be either direct through predation and indirectly through competition among the surviving plankton. Some phytoplankton, like diatoms, become fossils that record changes in lentic environments.

Impacts to Cultural Resources:

Archeological Sites

It is unlikely that this alternative would have any significant impact on archeological sites. If there are unknown sites that are currently being altered due to current recreational use patterns, then those impacts would likely persist.

Historic Sites

Historic sites are unlikely to be effected by this alternative since recreational use would not be changed.

Impacts to Social Environment:

Land Use/Recreation

Angling is a recreational pursuit that is done by some wilderness users. Generally, fishing is not a primary purpose of going to the wilderness, but it is an aspect of many wilderness trips. Being status quo, this alternative should not have any adverse effect on fishing experiences. Other recreational activities around water like swimming and wading should not be affected by this alternative.

Opportunities to enjoy backcountry wildlife will probably decline. People who go to the backcountry to observe or photograph wildlife are likely to have an increasingly depauperate experience, especially people who remember the abundance of frogs that formerly existed in most of the Parks' high Sierran waters. As the frogs continue to decline, there will be less opportunities for people to experience walking along a lake shore and seeing hundreds of large frogs jumping into the water. There will be less opportunities for people to see hundreds to thousands of large tadpoles glide through the water and dot the bottoms of ponds and lakes. There will few opportunities for visitors to see the water explode into bubbles and foam as schools of tadpoles are startled from their favorite warm-water-spots in the shallow margins of lakes.

Solitude/Noise

Being status quo, this alternative should have no significant influence on solitude.

Wilderness

Some people associate fishing with a wilderness experience. They would benefit from this alternative. Some people link wilderness to pristine conditions untrammeled by people. Under this alternative, the lakes would least resemble a pristine condition since the fish are not native. The fish and their impacts exist only because of human intervention. This alternative deviates most from wilderness as defined in the Wilderness Act (16 USC 1131 et seq.).

Economy

Again, being status quo, this alternative is not expected to have any influence on the local economy. There may be some long-term loss of backcountry users who wish to see wildlife as frog populations continue to decline. This is not expected to be significant.

Conclusions:

Existing impairment is expected to increase significantly as frog populations continue to decline. This is likely to result in local frog extirpations. The cumulative impact of extirpations is increased fragmentation and isolation of extant populations. This will facilitate potential extinction of mountain yellow-legged frogs. Large aquatic invertebrates will continue to be virtually absent from lakes occupied by fish, and the natural ecology of these waters and portions of the terrestrial environment will not function naturally due to the loss of frogs and large invertebrates. Much less energy will be transferred to the terrestrial environment as garter snakes, Clark's nutcrackers, blackbirds, coyotes and other terrestrial predators lose frogs as a source of food. Without frogs to prey on terrestrial invertebrates, some capture of energy from the terrestrial environment will be lost. Where lakes and ponds loose their frogs, there may be some subtle changes to the aquatic vegetation as a result of changes in nutrient inputs from frogs and loss of grazing by tadpoles. Unnatural depositional environments will continue to exist and may expand as more frog populations disappear. No significant changes are expected to terrestrial vegetation damage associated with human use of the sites, nor are changes expected to air, water, or cultural resources. Anglers will continue to have the same number of fishing opportunities, but wilderness users will have fewer opportunities to observe natural wildlife, though they may see more mosquitoes. This alternative is most out of phase with wilderness. Changes are not expected to the local economy.

Alternative 2, Restore Select High-benefit Low-use Lakes (Preferred Alternative)

Impacts to Natural Environment:

Wetlands and Vegetation

Terrestrial vegetation around the treatment sites is not expected to change significantly. This alternative could provide some benefit to vegetation by reducing trampling from angler use around some lakes. However, the benefit is expected to be insignificant since most of the lakes are in areas that currently receive no to insignificant use by either anglers or other people engaged in aquatic recreation. There could be some increase in shoreline use if people come to the treatment sites to see the restored frog populations.

Aquatic vegetation may change some due to the increased grazing by restored tadpole populations and from restoration of natural invertebrate communities. The nature of this change, if any, is unknown, but would be toward a more natural system.

There will temporary minor disturbance of the vegetation caused by two to four people camping and working in the vicinity of the treatment sites. These camps are expected to last about a month for two successive years. Crew camps would avoid vegetation and would use minimum impact camping techniques, and there should be no visible evidence of these camps when they are abandoned.

Wildlife, Vertebrates

In four areas, existing mountain yellow-legged populations would become more stable by increasing connectivity and reducing isolation between existing lakes and ponds, by restoring available habitat, and by increasing opportunities for over-wintering. This will allow them to deal more successfully with the consequences of local catastrophic events by allowing emigration from unaffected sites. Any improvement to the stability of frog populations will also benefit their predators, and facilitate more natural consumption of traditional frog prey species.

Each site will benefit in slightly different ways. At Sixty Lake Basin, the restoration will improve connectivity and gene flow between the southeastern, southern, and eastern populations. There will be some improvement in connectivity between the eastern and western frog populations by reducing the width of the area occupied by fish separating them. In the small basin east of Helen Lake, the restoration will allow the residual frog population to have winter access to deep waters and restore a metapopulation structure to the basin. Threats from stream fish would be reduced. The small basin west of Center Basin would regain frog winter habitat in its largest lake, improve basin connectivity, and reduce the threat of fish getting into other lakes in the basin. Removing fish from the one lake in Center Basin will give those frogs an opportunity for a deep-water over-wintering site and a place to escape from fish in the remaining lakes.

Crew camps are likely to attract bears and other wildlife. These camps are expected to last about a month for two successive years. Crews would use bear-proof food storage devices to prevent generating bear problems. Fish that are removed from gill nets would be sunk in lakes to prevent attracting bears. Stock would cause temporary damage to the vegetation if needed to haul heavy equipment or supplies to the camp.

Wildlife, Invertebrates

Within the eleven lakes from which fish were removed, large invertebrates should return to the water column. These include water boatmen (Corixidae) and large zooplankton like *Hesperodiaptomus* sp. and *Daphnia middendorffiana.* Mosquito (Culicidae) larvae should be less abundant. There should be a significant increase in visible small wildlife.

Threatened, Endangered, or Sensitive Species

This alternative would benefit these species by helping to reverse the decline of mountain yellow-legged frogs. This benefits the frogs and any listed or sensitive species that might feed on the frogs.

Water

In the long term, the water chemistry is not expected to change. If changes did occur, they would represent a more natural condition since the fauna would be more like that of pristine conditions. There may be a slight short-term increase in nutrients as fish, which are destroyed, decompose on the bottoms of lakes. Disposal on shore would likely cause bear problems. If any gill nets fragments were lost to bottom snags, the lost net material would add anthropogenic litter to the lake. Every effort will be made to avoid that happening.

Air

Air quality should remain unchanged by this alternative. Some pollutants would be added to the environment by burning fossil fuels for cooking. If the helicopter is needed, it would add pollutants to the air during its flight to an from the heliport.

Geologic Resources/Substrate

The removal of fish should restore biota within the water column to a more natural composition. This should result in a more natural depositional record on the bottoms of lakes and ponds.

The soil will experience temporary minor disturbance from two to four people camping in the vicinity of the treatment sites. These camps are expected to last about a month for two successive years. Crews would use minimum impact camping techniques, and there should be no visible evidence of these camps when they are abandoned. Stock would cause temporary damage to the substrate if needed to haul heavy equipment or supplies to the camp.

Impacts to Cultural Resources:

Archeological Sites

Because this restoration is entirely in the water, there should be no risk to any archeological sites that could be in the area. No archeological sites are currently known in the area. The lake treatments will not cause any disturbance of the soil. Crews will be advised not to disturb any observed archeological materials. Restoration crews could improve what is known about backcountry sites by reporting any archeological materials observed.

Historic Sites

This restoration should not have any potential to impact historic sites. There are no known historic sites at any of the proposed treatment sites. If any old structures are observed, they will remain undisturbed and reported to the Park Archeologist.

Impacts to Social Environment:

Land Use/Recreation

This alternative will remove angling opportunities from eleven lakes totaling 45 acres and up to 2.3 miles of stream. This will not be significant since these sites receive little to no angling use now. The heaviest use would be the lakes in the Sixty Lake Basin area. The entire basin receives about thirty to sixty people-days annually. Of the few that fish, most go to the lower portion of the basin (Vredenburg, per. comm.).

This restoration should create new opportunities for enjoying nature by restoring frog and aquatic invertebrate populations at these eleven lakes. The benefits should extent beyond the immediate lakes being restored and elevate frog populations throughout each small basin.

Solitude/Noise

This alternative should have no impact on solitude except during the restoration when two to four people will be in each area for two to four weeks and intermittently for several weeks thereafter to assure that fish removals are complete and to document post-treatment conditions. The restoration is not expected to cause any changes in the utilization of the area.

During restoration, if there is a need to get heavy equipment into the treatment site, like large bear-proof food-storage boxes, solitude would be interrupted for about ten minutes as a helicopter drops off and picks up a load. This is not expected to happen more than twice at each treatment area for each of two years, and may not be necessary. Stock would be used where more feasible to haul heavy loads.

Wilderness

People who associate fishing with a wilderness experience would find this alternative to be unfulfilling. People who link wilderness to pristine conditions untrammeled by human influences would find satisfaction in this alternative. This alternative is consistent with wilderness as defined in the Wilderness Act (16 USC 1131 et seq.).

Economy

Because this alternative is not expected to result in any change in the use of the area, it should have no measurable effect on the economy. The staff hired to implement the restoration will bring a meager benefit to the areas where they buy personal supplies.

Conclusions:

Impairment of natural resources should be reduced significantly or eliminated from the treated sites, and naturally functioning systems would be restored as the native aquatic biota return. This alternative has the most potential for benefiting mountain yellow-legged frogs and associated aquatic environments because this alternative's sites have the highest probability for successful removal of fish using gill nets. This alternative should restore connectivity to frog populations within and adjacent to the treatment sites and provide deep-water over-wintering habitat for frogs and tadples. This should not only increase the number of frogs, but also increase stability of extant populations in the vicinity of the treatment sites. Large macroinvertebrates like water boatmen and large zooplankton should return to the water column within treated lakes. There may some change to the algae and other aquatic vegetation in lakes due to grazing by restored tadpole and invertebrate populations. Natural depositional environments will be restored to lake and pond bottoms. No significant changes are expected to water chemistry, air, or vegetation and cultural resources adjacent the treatment sites. The restoration should have no lasting impact on solitude or the economy. The restoration will reduce fishing opportunities, but it will increase opportunities for wildlife viewing. The alternative is consistent with wilderness management. There will be some temporary impacts associated with restoration crews being present during the restoration effort.

Alternative 3, Restore Select High-benefit Moderate-use Lakes:

Impacts to Natural Environment:

<u>Wetlands and Vegetation</u>

The benefits to terrestrial vegetation could be slightly greater than Alternative 2 because these proposed treatment sites receive slightly more visitation and probably more angling than the sites in Alternative 2. However, since angling is not a significant use of these sites, removal of fish should only have minimal benefit to the vegetation. Vegetation lost to social trails is not a significant problem at these sites, and current social use patterns are not expected to change significantly following restoration.

<u>Wildlife, Vertebrates</u>

In two areas, existing mountain yellow-legged populations would become more stable. At Sixty Lake Basin, the restoration will improve connectivity and gene flow between the western and southern populations. There will be some improvement in connectivity between the eastern and western frog populations by reducing the width of the area occupied by fish separating them. It will create a fish-free area around one of the most important breeding sites in the entire basin, and it will increase over-wintering habitat. In the Wanda Lake area, it will remove fish from an upstream source (Lake McDermand) that threatens frogs at Wanda Lake. Data on Wanda Lake are conflicting with only one investigator finding fish there. Wanda appears to be very marginal fish habitat in which fish occasionally arrive from upstream sources but don't breed. Wanda will need to be reexamined before proceeding to the two lakes below it. Once all fish are removed, deep-water wintering habitat will be increased significantly. Connectivity will be enhanced and the metapopulation structure would be improved in the upper part of the drainage.

This alternative has the most potential for restoring area (75-216 acres depending on whether or not Wanda Lake was counted and less than 0.8 mile of stream), but it also has the highest potential for failure using gill nets. Fiord Lake in Sixty Lake basin is very deep, and success would depend on effectively setting gill nets in the known spawning area early in the season and repeating the treatment as the fish reach spawning age. Any fish that are missed would threaten downstream treatments. The same problem exists at Wanda Lake. The lake is huge (141 ac) by Sierran standards. Any fish missed in Wanda Lake could swim to downstream treated lakes and ruin that effort. In the future, other treatment alternatives might be more suitable for such large lakes.

Wildlife, Invertebrates

If fish removals would be successful, large aquatic invertebrates should return to the nine lakes from which fish would be removed.

Threatened, Endangered, or Sensitive Species

Same as Alternative 2.

Water

Same as Alternative 2.

Air

Same as Alternative 2.

Geologic Resources/Substrate

Same as Alternative 2.

Impacts to Cultural Resources:

Archeological Sites

Same as Alternative 2.

Historic Sites

Same as Alternative 2.

Impacts to Social Environment:

Land Use/Recreation

This alternative would cause a slight reduction in angling by eliminating it from the nine lakes included in this proposal. The reduction would be most likely to occur at the first lake below Wanda Lake because it is very accessible and some people camp there. In Sixty Lake Basin, there would probably be less effect. Most of Fiord Lake lacks a shoreline suitable for fishing, and most visitors walk by Cotter Lake on their way to Gardiner Basin.

The alternative should provide new opportunities to enjoy wildlife at the same locations. Mountain yellow-legged frogs and large aquatic invertebrates should become much more visible within the project area.

Solitude/Noise

Same as Alternative #2.

Wilderness

Same as Alternative #2.

Economy

Same as Alternative 2.

Conclusions:

The conclusions are nearly the same as Alternative 2. This alternative has potential to provide the most restored habitat, but the likelihood of reducing impairment would be less than Alternative 2. This is because there is a lower probability for success due to the difficulty of treating large lakes with gill nets. Because these sites get more visitation than those in Alternative 2, there could be more impact to anglers but better opportunities for wildlife viewers to observe frogs and aquatic invertebrates if restoration is fully successful.

Alternative 4, Restore Select High-benefit Mix of High-use and Obscure Lakes

Impacts to Natural Environment:

Wetlands and Vegetation

This alternative is not expected to have any significant influence on vegetation. One of the sites (in Swamp Lakes Basin) is in one of the least visited areas in the entire park. The lakes east of Bench Lake are also at unlikely locations for visitation. The two lakes in upper Dusy Basin receive some of the heaviest use in these Parks. A social trail partially surrounds the larger lake, but fishing is not a significant activity there. The loss of fish from that site should cause little benefit, if any, to the vegetation since trampling from camping will probably continue.

Wildlife, Vertebrates

This alternative should help restore frog populations in seven lakes (24 acres) and less than 1.8 miles of stream distributed in three areas. At both lakes in upper Dusy Basin and the lakes east of Bench Lake, fish removal would provide deep-water habitat for over-wintering and improve connectivity between existing habitable sites. It would improve metapopulation structure within those portions of each basin. The one lake in the Swamp Lakes basin is the only lake that has a fish population. Removal of fish from the lake and downstream areas could result in an entire major basin having connectivity restored. However, since the surveys were limited to lakes and ponds, it is possible that additional stream populations of fish exist. When this frog populations was surveyed in 2000, mountain yellow-legged frog tadpoles were infected with Chytrid fungus, and it is possible that this basin is being influenced by contaminants from the Central Valley. While this area has great biological potential for a large basin with nearly no human use, the future success of frogs in this basin is questionable.

Some of the expanded population of frogs at the Dusy Basin site may be lost to curious careless adults catching and mishandling frogs. This loss is speculative and not expected to be significant.

Wildlife, Invertebrates

Large aquatic invertebrates should be restored to the water column in each of the seven lakes from which fish would be removed.

Threatened, Endangered, or Sensitive Species

Same as Alternative 2.

Water

Same as Alternative 2.

Air

Same as Alternative 2.

Impacts to Cultural Resources:

Archeological Sites

Because this restoration is entirely in the water, there should be no risk to any archeological sites that could be in the area. The lake treatments will not cause any disturbance of the soil. Crews will be advised not to disturb any observed archeological materials. Restoration crews could improve what is known about backcountry sites by reporting any archeological materials observed. Some archeological sites consisting of lithic scatter are known from the treatment site at Dusy Basin. This is a very high use area. The presence of the crew could temporarily increase security of that site by creating an employee presence there.

Historic Sites

Same as Alternative 2.

Impacts to Social Environment:

Recreation

This alternative would eliminate angling opportunities at seven lakes and up to 1.8 miles of stream. Due to the lack of existing use, it is unlikely to cause any actual changes at any of the sites except the two lakes in upper Dusy Basin where visitation is heavy.

This alternative should create new opportunities for enjoying wildlife though this will probably only be realized at the Dusy Basin site. Successful restoration of that site could result in better opportunities for backcountry visitors there to see, study, and enjoy mountain yellow-legged frogs.

During treatment, crews will have to monitor the gill nets especially closely to assure that they are not disturbed and to assure that people do not swim near the nets. The area will require signing for safety.

Solitude/Noise

Same as Alternative 2.

Wilderness

Same as Alternative #2.

Economy

Same as Alternative 2.

Conclusions:

The conclusions are nearly the same as Alternative 2. This alternative has the least potential to provide restored habitat because of the combined acreage of the sites is least. The likelihood of reducing impairment is slightly less than Alternative 2 because the cumulative area for treatment is less, Chytrid fungus is known to heavily infect tadpoles at one of the sites, and high visitation at the upper Dusy Basin site may interfere with successful restoration of that site. If successful, this alternative would provide the greatest range of sites along a public use spectrum. These sites range from some of the most heavily used lakes at upper Dusy Basin to sites that almost never see people at Swamp Lakes Basin. The upper Dusy site would have the most pronounced impact on potential anglers, but it would also provide the best opportunity to restore frogs in a high-use area for wildlife viewing.

Environmentally Preferred Alternative:

Alternative 2 is the environmentally preferred alternative because it has the most chance of correcting existing impairment within the project area. Alternatives 4 is a close second because it is technically feasible but mitigates impairment within a smaller area and is more likely to have restoration problems with one site heavily infected with Chytrid fungus and another with high visitor use. Alternative 3 is third choice for the environmentally preferred alternative because the large size of the lakes will challenge the park's likelihood for success at mitigating existing impairment using gill nets to remove the fish. The no action alternative (Alternative 1) least resembles the environmentally preferred alternative. It would likely increase impairment by failing to restore natural aquatic systems and allowing the current frog decline to continue.

Consultation and Coordination

The Parks' Fish and Wildlife Biologist, Harold Werner, prepared this document in consultation with the frog biologists that are familiar with the species (Dr. Roland Knapp and Vance Vredenburg) and the Environmental Management Committee at Sequoia and Kings Canyon National Parks.

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Appendix

Impact Mitigation Matrix for Preferred Alternative:

Impact	Mitigation
Trampled terrestrial vegetation during fish removal and campsite occupation	- Careful selection of footgear; - Crew planning to avoid unnecessary trampling; - Use of minimum impact camping techniques
Crew camp could attract bears and other wildlife.	Crew would use bear-proof food-storage containers
Short-term increase in lake nutrients from fish disposal	Time (estimate 1 year)
Air pollution from the crew cooking on gas stove and possible helicopter support for heavy gear	- The gas stove is the most environmentally friendly source of cooking heat available. - Use of the helicopter will be avoided if feasible alternative is available.
Removes angling from eleven lakes.	Existing angling at those eleven lakes is insignificant. Numerous alternative site will remain for angling.
Solitude will be compromised at the eleven lakes while the crew is restoring them.	Time (estimate 2-4 weeks for each of 2 years)
Possible helicopter noise for several ten minute periods	- Avoid use is feasible; - Time (estimate 10 minutes)