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Decline of Frog Species in the Yosemite Section of the Sierra Nevada

Charles A. Drost and Gary M. Fellers

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United States Department of the Interior
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The University of California, Davis

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DECLINE OF FROG SPECIES IN THE YOSEMITE SECTION OF THE SIERRA NEVADA

Charles A. Drost and Gary M. Fellers

June 1994

Note:

By action of Secretary of the Interior Bruce Babbitt, the research function of the National Park Service and several other Interior agencies was tranferred to a newly created agency, the National Biological Survey, on November 12, 1993. At this time, the National Park Service employees of the Cooperative National Park Resources Studies Unit in California became employees of the National Biological Survey. The NBS is establishing new guidelines and procedures for technical reports and other publications of the agency. During Fiscal Year 1994, this technical report series will continue to be produced under the National Park Service logo, publication policies, and numbering system.

S. Veirs 4/94

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Abstract

Many species of frogs and toads from areas all over the world have suffered serious population losses in the last 12 - 20 years. The magnitude and extent of declines have been difficult to determine because of a lack of baseline data. We repeated an intensive survey conducted in 1915 by eminent zoologists Joseph Grinnell and Tracy Storer (*Animal Life in the Yosemite*, University of California Press, 1924) to assess the seriousness of amphibian declines in the Yosemite area of the Sierra Nevada mountains.

In our 1992 surveys of the Grinnell and Storer sites, all seven native frogs showed evidence of decline. The foothill Yellow-legged Frog (*Rana boylii*) has apparently been extirpated from the region, and the mountain yellow-legged frog (*R. muscosa*), formerly the most abundant species in the region, has been reduced to a few small isolated populations. The Yosemite Toad (*Bufo canorus*), whose entire range is restricted to high elevations in the Sierra Nevada, has disappeared from half of the sites where it was originally found by Grinnell and Storer. Even the Pacific Treefrog (*Pseudacris regilla*), which is widespread and common across much of the western U.S., showed significantly reduced numbers at higher elevations. The declines we documented have occurred relatively quickly, and the cause (or causes) remains unclear.

We believe these declines, affecting the entire frog and toad fauna, are among the most serious and urgent conservation concerns in the Yosemite region today. Further research into the losses is urgently needed, and concerted management efforts will probably be required to restore severely depleted populations to former levels. Greatest management needs include close monitoring of known populations, surveys for additional viable populations, intensive research into the cause of the declines, and carefully observed reintroduction projects.

Introduction

WORLDWIDE FROG DECLINE

Historically, amphibians have not received the conservation concern accorded groups such as birds and large mammals. This is due in part to less popular interest in amphibians as a group, but it is also due to relatively poor knowledge of population size and trend for most species. The few species that have received official attention, including the Pine Barrens Treefrog (*Hyla andersoni*) in the northeast, the Gopher Frog (*Rana areolata*) in the southeast, and the Red-legged Frog (*R. aurora*) in the Pacific states, have suffered due to extensive habitat loss or habitat alteration.

In the last few years, however, it has become apparent that there have been large population declines in frog and toad species all over the world (Barinaga 1990, Blaustein and Wake 1990, Wake 1991, Wake and Morowitz 1990, Wyman 1990). The declines appear to have occurred relatively quickly, and have affected species in diverse habitats on all continents where amphibians occur. The cause of the declines is not known, nor is it known whether there is a single cause or a coincidental series of local factors; speculation ranges from acid precipitation and increased ultraviolet radiation to habitat degradation and loss.

Several frog species in the western United States are among those that have suffered major declines. These include formerly widespread and abundant species such as the Western Toad (*Bufo boreas*) in the Rocky Mountains (Carey 1993), the Mountain Yellow-legged Frog (*Rana muscosa*) in the mountains of California (Bradford et al., ms.), the Spotted Frog (*Rana pretiosa*) in the Pacific Northwest (Hayes and Jennings 1986, Leonard 1992), and the Northern Leopard Frog (*Rana pipiens*) over much of the western U. S. and Canada (Corn and Fogleman 1984, Hayes and Jennings 1986). Some species of more limited distribution, such as the Wyoming Toad (*Bufo hemiophrys*) and the Relict Leopard Frog (*Rana onca*) are now close to extinction (e.g. Beiswenger 1990).

THE FROG FAUNA IN THE YOSEMITE AREA

There are seven species of native frogs and toads known from the Yosemite region of the California Sierra Nevada. The Great Basin Spadefoot Toad (*Scaphiopus intermontanus*) extends into the extreme eastern portion of this area, in the vicinity of Mono Lake. There are two true toads: the Western Toad occurs at lower elevations on both sides of the mountains, and ranges into Yosemite National Park along the floor of Yosemite Valley; the Yosemite Toad (*Bufo canorus*) is a high elevation species (2,000 m and higher) that is endemic to the southern and central Sierra Nevada, with Yosemite

National Park forming the heart of its range. Three true frogs include the Red-legged Frog, a lowland species that ranges into the western foothills of the Sierra Nevada, and two species of Yellow-legged Frogs. These are the Foothill Yellow-legged Frog (*Rana boylii*), which ranges along the western side of the Sierra Nevada up to middle elevations, and the Mountain Yellow-legged Frog (*R. muscosa*), the high elevation counterpart to the former species, distributed throughout the axis of the Sierra Nevada at elevations up to 3,600 m. Finally, there is one treefrog, the Pacific Treefrog (*Pseudacris* [= *Hyla*] *regilla*), which is distributed throughout the region.

Five of the native frog species - the Western Toad, Yosemite Toad, Red-legged Frog, Foothill Yellow-legged Frog, and Mountain Yellow-legged Frog - have experienced declines in other parts of their ranges. Decimation of formerly large populations of the Western Toad was first noted in the southern Rocky Mountains in the early 1980's (Carey 1993, Yoffe 1992). More recently, Blaustein and Olson (1991) reported large-scale breeding failures of this species in the Oregon Cascades. Several studies have documented population declines in the Yosemite Toad. Martin (1991a) surveyed approximately 110 historical localities across the range of the species and found that the toads had disappeared from nearly half of the sites, and were significantly reduced in numbers at the remaining sites. A formerly large population in the meadows of Tioga Pass has experienced a sharp decline over the last 20 years (Kagarise Sherman and Morton 1993).

All three of the ranid frogs (genus *Rana*) have declined throughout parts of their respective ranges. The Red-legged Frog has become rare over much of its range in California (e.g. Hayes and Jennings 1986, Moyle 1973). Extensive habitat alteration and destruction, and predation by introduced fish are suspected as the main causes for the species' decline (Hayes and Jennings 1986, Jennings 1988). Recent surveys throughout the southern Sierra Nevada foothills did not locate any surviving populations of the foothill yellow-legged frog (Graber, pers. comm.) and Sweet (1983) reported on the disappearance of foothill yellow-legged frog populations in southern California. The mountain yellow-legged frog was formerly very abundant in high-elevation lakes throughout the Sierra Nevada and in parts of the peninsular ranges of southern California. Extensive surveys in the Sequoia and Kings Canyon area found the species had disappeared from approximately half of the sites where it formerly occurred (Bradford 1989, Bradford et al. 1991a, Bradford et al. ms.). Predation by non-native fish, acidification of surface waters, and fragmentation and isolation of remaining populations have all been considered as possible causes for the disappearance of this once abundant species (Bradford 1989; Bradford and Gordon 1992; Bradford et al. 1991b, 1991c, 1993).

THE GRINNELL SURVEY

Part of the problem in evaluating the nature and extent of amphibian declines has been a dearth of quantitative background information on amphibian populations in most areas. This is especially true of Yosemite, where recent information on amphibian populations is in the form of short, anecdotal articles on "new" species for the Park, or unusual occurrences (e.g. Camp 1916, Martin 1940, Richards 1958). There is, however, a largely overlooked older source of baseline information on vertebrate populations within Yosemite. During the period 1914 - 1920, a team of zoologists from the University of California led by Joseph Grinnell and Tracy Storer conducted an extensive study of the vertebrate animals that occurred along a transect across the Sierra Nevada through Yosemite National Park (Figure 1). Grinnell and Storer's team sampled and made observations of animal species at 40 stations along this 144 km strip extending from La Grange at the edge of the Central Valley to Mono Lake on the east side of the Sierra Nevada (Table 1). Grinnell and Storer and six other field personnel spent a total of 957 days collecting and making observations. Most of the field work was conducted in 1915, with additional observations from short trips in 1919 and 1920. The areas visited ranged from 75 m at Snelling to 4,000 m on Mt. Lyell, and covered all of the life zones in the area, from Lower Sonoran to Arctic Alpine. In addition to recording general distribution and numbers for each species, the Grinnell and Storer team put a substantial amount of time and effort into recording natural history data such as habitat associations and reproduction. (Grinnell and Storer 1924, pp. 1-21; also original field notes from survey members).

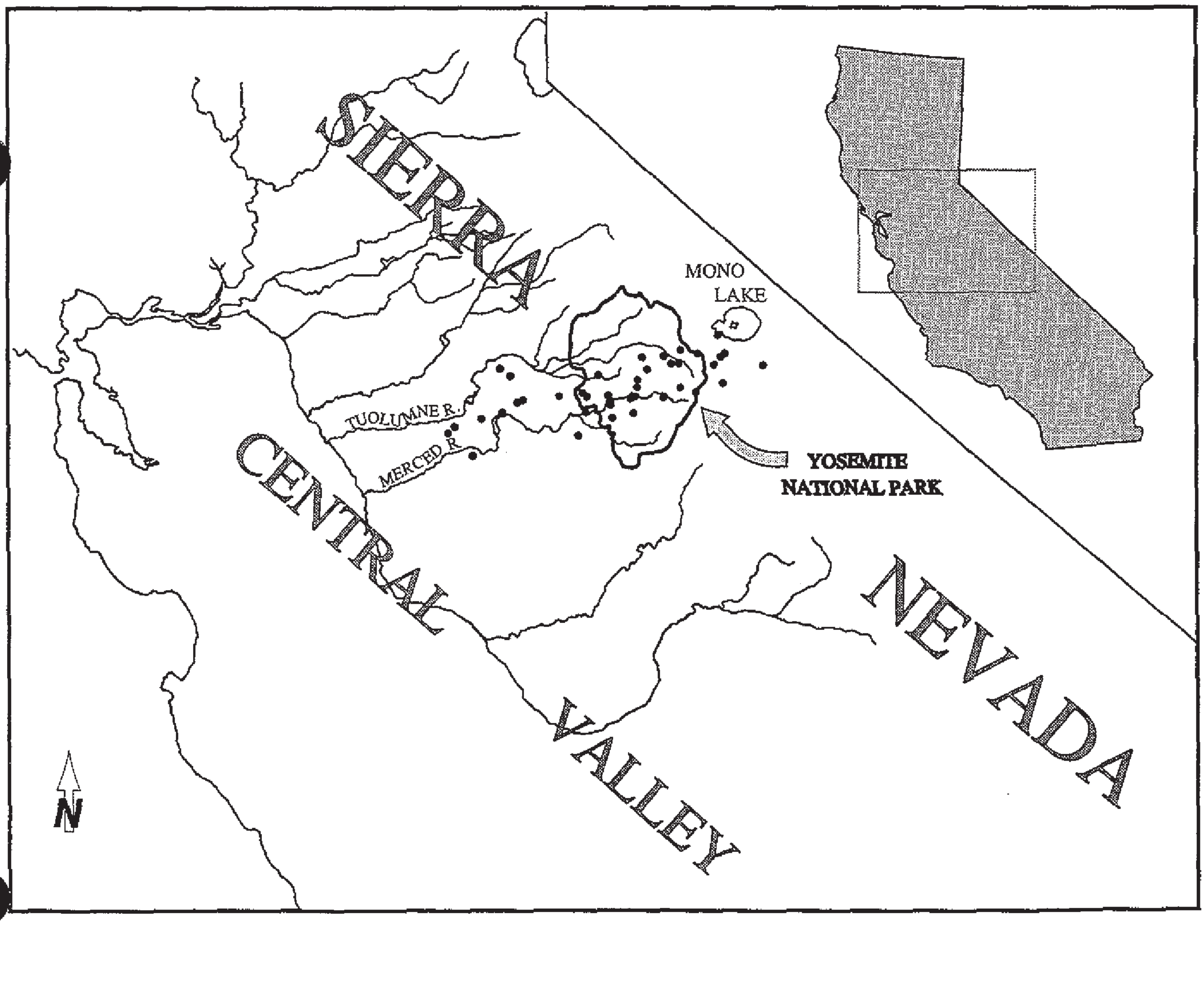
THIS STUDY

To evaluate changes that have occurred in the amphibian fauna of the Yosemite area, we resurveyed the Yosemite transect during the spring and summer of 1992. We revisited the original Grinnell and Storer sites and made intensive searches for the frog species known from the area. We also noted general habitat condition and collected information that might be related to the decline of amphibian populations. This report details the methods and findings of the 1992 survey, compares these findings with the Grinnell and Storer survey, and makes recommendations on management action needed to protect the amphibian fauna within Yosemite National Park.

Methods

We reviewed both the final report of the Grinnell and Storer study (Animal life in the Yosemite, Joseph Grinnell and Tracy I. Storer, University of California Press, 1924), and the original field notes of all of the persons who participated in the survey, including Grinnell, Storer, Charles L. Camp, Joseph Dixon, Gordon Ferris, Charles D. Hollinger,

Figure 1. Location map of Yosemite National Park in the Sierra Nevada of central California, showing areas sampled in 1992 and 1993 in a survey of amphibian distribution and population status. Sites visited ranged from the Sierra Nevada foothills on the west, through Yosemite National Park, to Mono Lake on the east side of the Sierra Nevada crest.



Walter P. Taylor, and Donald D. McLean [1]. From their maps and descriptions, we located as closely as possible the exact sites they visited. In many instances, the Grinnell and Storer survey members moved about extensively. When this was the case, we made particular note of the specific locations where they reported on amphibians. We recorded and tabulated the survey members' observations and notes, which provided information on distribution and numbers of amphibians, as well as on time of activity, habitat use, and notes on reproduction and other aspects of the species' ecology.

In addition to the Grinnell and Storer sites, we visited a number of other areas with previous records of frog presence and abundance, either from museum records or from our own earlier observations. We also surveyed additional lakes, meadows and other sites along the transect that appeared, based on field inspection or examination of maps and aerial photos, to offer suitable habitat for frogs.

One or both of the authors visited each of the survey sites during the spring and summer of 1992. At each site, we thoroughly searched all aquatic habitats that were suitable for frogs. At some pond and meadow sites we stayed into the evening to listen for calling frogs. Our usual search technique consisted of crisscrossing meadow areas and making thorough searches of the margins of streams, lakes and ponds. In meadows, we looked for all areas of standing water and made a careful search of these, either by wading through the area or by walking the circumference of larger, deeper bodies of water.

For streams, we walked along the shore or waded the length of stream described in the Grinnell and Storer field notes. When the exact area covered was not evident, or when we were surveying areas not surveyed by Grinnell and Storer, we walked sections of stream that appeared to offer good habitat, and recorded an estimate of the length of stream covered. In streams, we paid particular attention to exposed rocks and logs in the stream, and to exposed areas along the banks, which are typical resting spots for stream frogs. We also checked quiet pools along the stream course, where tadpoles might be expected.

Around potholes, ponds, and lakes we looked for adult frogs sitting along the shore or in the shallows, and scanned the near-shore waters for tadpoles. In water that was turbid or had extensive aquatic plants, long-handled nets were used to sweep for tadpoles. Large lakes, rivers, and large streams that contained fish were given more cursory checks, as Sierran frogs rarely occur in waters containing large fish (see, e.g., Bradford 1989; Grinnell and Storer 1924, p. 664; Yoon 1977). An exception to this is large lakes that have extensive weedy shallows, as, for example, around the west end of Merced Lake and the east end of Dog Lake. These areas provide protection for adult frogs and tadpoles from predatory fish, and we searched these shallows and weedy edges in a more thorough manner, similar to our surveys of fishless habitats.

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1. Original field notes for all participants in the survey except Storer are maintained at the Museum of Vertebrate Zoology, University of California, Berkeley, CA. Tracy Storer's field notes are maintained at the California Academy of Sciences, San Francisco, CA.

Some species such as the Yellow-legged Frogs are closely tied to the margins of lakes and streams and tend to sit out in the open where they are relatively conspicuous, and we considered our coverage of sites to be exhaustive, or nearly so, for these species. The two *Bufo* species can be relatively retiring and cryptic, so the methods used here do not reflect total numbers in the area, but should adequately represent presence or absence and relative numbers. Spadefoot toads spend much of their time underground, emerging during and after summer rains to breed in temporary pools. For this reason, it can be difficult to determine their presence or absence in an area, and our coverage of the eastern Sierra Nevada sites may not have been sufficient to locate Great Basin Spadefoots.

Tadpoles of all species could be reliably identified in the field. Tadpoles were generally easy to find in areas where they occurred and, since we thoroughly searched all sites visited for tadpoles, this provided good corroboration of the presence or absence of different species at a site, as well as reflecting reproductive effort and success. For some species, such as the toads, presence of tadpoles provided the best indication of the occurrence and relative abundance of the species.

Results

FIELDWORK

Between May 11 and September 11, we visited 38 of Grinnell and Storer's 40 collecting sites (Table 2). Grinnell and Storer either did not find or did not provide specific information on amphibians at their Chinquapin, Aspen Valley, Warren Fork, and Gem Lake sites. We surveyed Aspen Valley and Chinquapin, but did not hike in to Warren Fork and Gem Lake. Also, we were not able to distinguish amphibian observations recorded by Grinnell and Storer for the two LaGrange sites, the two Yosemite Valley sites (Yosemite Valley and Leidig Meadow), the two Cascades Creek sites, and the two Tuolumne Meadows sites, so we lumped these observations into one site for each of the original pairs of sites. For this reason, we were only able to directly compare our data for 32 of the 40 originally designated collecting stations. However, many of the observations recorded by the Grinnell and Storer team were made on excursions away from the designated collecting stations. For sites where Grinnell and Storer recorded sufficient detail for discrete sites away from the designated collecting stations, we visited and recorded data separately for these sites. There were six such additional sites (Table 3), so the total number of comparisons between our surveys and those of Grinnell and Storer was 38. Taking together the Grinnell and Storer sites and the additional sites we surveyed (Table 3), we report here information on frog presence and abundance at a total of 63 sites (Figure 1; Appendix 1).

During the course of the late spring and summer, we spent a total of 44 person-days surveying for amphibians. This represented approximately 103 hours surveying designated

Table 1. Collecting sites of the Grinnell and Storer survey of the "Yosemite Section", listed west to east. Names marked by an asterisk are our own names for sites not given a map label by Grinnell and Storer. Names in parentheses are alternate names we use in this report. Location and general description of each site is provided in Appendix 1.

West side:

Privately owned
- La Grange / West*
- La Grange
- Snelling
- Piney Creek
- Pleasant Valley
- Blacks Creek

Stanislaus and Sierra National Forest
- McCarthy Ranch
- Smith Creek / Dudley
- Feliciana Mountain / Sweetwater Creek
- Hazel Green

Yosemite National Park
- Merced Grove
- Crane Flat
- Aspen Valley
- El Portal
- Tamarack Flat
- Chinquapin
- Cascade Creek - south
- Cascade Creek - north
- Leidig Meadow* (Yosemite Valley West)
- Mono Meadow
- Indian Canyon Creek (including Indian Canyon and Lehamite Creek)
- Yosemite Valley (Yosemite Valley East)
- Porcupine Flat
- Ten Lakes
- Snow Creek* (Mt. Hoffmann)
- Glen Aulin / McGee Lake
- Tuolumne Meadows (west)
- Merced Lake (and Merced River and Little Yosemite Valley to Sunrise Creek)
- Tuolumne Meadows east
- Young Lakes (3 sites) / Ragged Peak
- Vogelsang Lake
- head of Lyell Canyon

East side:

Inyo National Forest
- Warren Fork (NE of Tioga Pass)
- Walker Lake
- Gem Lake
- Mono Lake
- Rush Creek*
- Walker Creek*
- Farrington Ranch
- Mono (Dry Creek, Mono Mills)

Table 2. Timing of fieldwork during the 1992 survey of the Yosemite transect of Grinnell and Storer - main sites surveyed during each trip, and personnel conducting surveys (complete listing of sites visited, and results of surveys, are given in Appendix 2). Abbreviations for observers are the authors (CAD, GMF) and Park Service volunteer Rebecca Hamman (RH).

Dates	Observers	Sites surveyed
May 11-14	GMF/CAD	La Grange /West, Snelling, Smith Creek, McCarthy Ranch, Blacks Creek, Piney Creek, Hazel Green, Merced Grove, Crane Flat, Yosemite Valley, Cascade Creek, El Portal, Feliciana Mountain
June 8-12	GMF/CAD	McCarthy Ranch, Aspen Valley, Peregoy Meadow, Mono Meadow, Summit Meadow, Chinquapin, Mono Lake, Walker Lake, Rush Creek, Mono, Farrington Ranch, Tioga Pass, Tuolumne Meadows, Porcupine Flat Tamarack Flat, Westfall Meadow
July 6-9	CAD/RH	Lyell Fork, Evelyn Lake, Fletcher Lake, Vogelsang Lake, Merced Lake, Merced River, Sunrise Creek
July 2-10, 13-15	GMF	Summit Meadow, Tuolumne Meadows, Young Lakes, Mt. Conness, Dingley Creek, Ten Lakes, Elizabeth Lake, Dog Lake, McGee Lake, Tioga Pass, Snow Flat, Porcupine Flat
August 3-6	CAD	Lyell Fork, Head of Lyell Canyon, Evelyn Lake, Mt. Hoffmann, Snow Flat
Sept 9-11	CAD	Summit Meadow, Indian Canyon Creek, Elizabeth Lake, Porcupine Flat, Mirror Lake / Yosemite Valley

Table 3. Additional sites visited in the 1992 survey, listed west to east. For sites denoted "GS" baseline data was taken from original field notes of the Grinnell and Storer team. "HIST" denotes sites for which we had other historical amphibian occurrence information, either from museum records or from earlier fieldwork by the authors. Remaining sites were checked because they appeared to offer additional suitable breeding habitat.

Yosemite National Park

- Summit Meadow (HIST)
- Westfall Meadow (GS)
- Peregoy Meadow (GS)
- G7 Meadow (HIST)
- Half Moon Meadow
- Mt. Hoffmann (HIST)
- Tenaya Lake
- Medlicott Dome (HIST)
- Babcock Lake
- Fletcher Creek
- Elizabeth Lake (HIST)
- Dingley Creek (GS)
- Dog Lake
- Fletcher Lake
- Evelyn Lake (GS)
- Lyell Fork of the Tuolumne River
- Mt. Conness / White Mountain (GS)
- Ireland Lake
- Simmons Peak
- Maclure Creek (including Maclure Lake)
- Upper Lyell Fork

Inyo National Forest

- Tioga Lake / Tioga Pass (GS)
- Bohler Canyon

sites (those sites noted by Grinnell and Storer), with the remainder of the time spent traveling to and from the designated sites and conducting surveys of other potential amphibian habitats. In addition, we were out on 17 evenings during May through August, listening for frog breeding choruses.

FROG DISTRIBUTION AND NUMBERS

All of the native frog and toad species were present at far fewer sites in 1992 than in 1916-1920 (Table 4). Foothill Yellow-legged Frogs were not found at any of the sites in 1992, despite careful searches. Western Toads were reduced to one site in the 1992 survey, and Mountain Yellow-legged Frogs to two. For both species, this is a decline of over 80% in number of sites occupied. Yosemite Toads were present at about half of the sites where they were found in the 1920 survey.

The Red-legged Frog and Great Basin Spadefoot range into the western and eastern edges of the survey area, respectively. Grinnell and Storer found these two species at three of their sites each. We found Red-legged Frog tadpoles at one of the supplemental sites that we checked (Cuneo Creek), however we did not find the species at any of the Grinnell and Storer sites. We did not find Great Basin Spadefoots anywhere along the transect. The change in number of sites occupied by these species was not statistically significant, but, as with the other species, the trend was downward. Of all of the frog species in the Yosemite section, only Pacific Treefrogs were still present in 1992 at most of the sites where they were found in the earlier survey. All other species had disappeared from places where the Grinnell team had found them (we did not find Pacific Treefrogs at six sites where they were found previously, but we also found this species at three "new" sites where Grinnell and Storer did not report them).

In addition to comparing simple presence / absence at the sites, we also analyzed changes in abundance between 1920 and 1992. For most of their survey sites, Grinnell and Storer only described abundance in a general way; they did not report counts or numerical estimates of abundance. For this reason, our evaluation of changes in abundance was limited to comparing relative abundance categories (e.g. rare, common, abundant). This comparison of relative numbers of frogs found at the sites in 1920 and 1992 shows a stronger downward trend for some species than a simple comparison of presence/absence at the different sites (Table 5). The Yosemite Toad showed obvious declines at eight of the 13 sites it originally occupied. For Western Toad, Red-legged Frog, and Mountain Yellow-legged Frog, there were decreased numbers at almost all sites where the species still occurred. No species except Pacific Treefrog showed apparent increases at any sites, and even for Pacific Treefrog there were declines at nearly 80% of the sites where there was an evident change in numbers.

Table 4. Frog populations found by Grinnell and Storer (1924) during their original survey of a transect across the Sierra Nevada through Yosemite National Park, compared to populations found during a survey of the same sites in 1992. "1920 sites" is the number of Grinnell and Storer's sampling sites at which they found the species. "1992 sites" is the number of the same sites at which we found the species. "% of 1920" is the number of 1992 sites as a proportion of the 1920 sites. "Losses" is the number of the 1920 sites where the species was not found in 1992, and "gains" is the number of sites where the species was found in 1992 but not in 1920 [1].

			Change		
Species	1920 sites	1992 sites	% of 1920	Losses	Gains
Western Toad	6	1	17%	5	0
Yosemite Toad	13	7	54	6	0
Pacific Treefrog	22	19	86	6	3
Red-legged Frog	3	0	0	3	0
Foothill Yellow-legged Frog	7	0	0	7	0
Mountain Yellow-legged Frog	14	2	14	12	0
Great Basin Spadefoot	3	0	0	3	0

1. *Rana catesbeiana*, the introduced bullfrog, has colonized some of the low elevation sites since the time of the 1920 survey. It is not listed here.

Table 5. Long-term changes in frog populations in a transect across the Sierra Nevada through Yosemite National Park: distribution and abundance reported during the period 1914 - 1920 (Grinnell and Storer 1924) compared with a replicate survey conducted in 1992. Table entries are the number of survey sites showing decrease, increase, or no discernible change between the two survey periods. Sites where there was not a definite, conspicuous change are listed in the "No change" category. Data for Pacific Treefrog are broken down further into low elevation sites [< 1500 m (5000 ft.)] and high elevation sites [≥ 1500 m (5000 ft.)]. P-values are based on a sign test.

Species	Decrease	Increase	No change	p-value
Western Toad	5	0	1	.03
Yosemite Toad	8	0	5	.004
Pacific Treefrog	11	3	11	.03
low elevation	3	2	4	.50
high elevation	8	1	7	.02
Red-legged Frog	3	0	0	.125
Foothill Yellow-legged Frog	7	0	0	.008
Mountain Yellow-legged Frog	14	0	0	.0001

SPECIES ACCOUNTS

In the following section, we recount distribution and relative abundance of each species as found by Grinnell and Storer in 1915 - 1920, and compare this to the distribution and numbers we found in the 1992 survey. We also provide a brief description of the habitat used by each species. Tables 4 and 5 give a numerical breakdown of the number of sites where species were found, and changes in numbers between 1920 and 1992. A detailed accounting of sites visited, dates of survey, species and numbers of frogs found, and notes on habitat is given in Appendix 2.

Western Toad (Bufo boreas)

Grinnell and Storer described this species as a "common resident" below 1360 m, from Snelling and LaGrange east to Yosemite Valley. They also found Western Toads at Walker Creek on the east slope of the Sierra Nevada. Grinnell and Storer's team found Western Toads to be "exceedingly abundant" at most localities in the western foothills, "probably in about the same numbers as were present before the country was settled." They noted, however, that declines had occurred even by the time of their surveys: "In most settled districts toads have suffered great decrease . . . incident to man's activities."

Of the six sites where Grinnell and Storer reported Western Toads, we found them at only one - Yosemite Valley. Even within the Valley, Western Toads were not numerous. We found a single adult female, dead of unknown causes, and 20 tadpoles in the meadow west of the Ahwahnee Hotel. A second large adult female was in Leidig Meadow, along with 30 tadpoles. There were also two groups of toad eggs in small pools within Leidig Meadow. We cannot tell from Grinnell and Storer's notes whether numbers in the Valley now are lower than at the time of their surveys.

Habitat at the Valley sites where Western Toads were found consisted of large, open, marshy sedge meadows. The only adults found were at breeding ponds. Tadpoles and eggs were in sedge-filled shallow pools within the meadows and, in one instance, in a silt-bottomed overflow pool along the Merced River. Non-native bullfrogs were generally distributed in the ponds and larger overflow pools throughout the Valley (see below). We do not know if the presence of bullfrogs has affected the distribution and numbers of toads in this area.

Yosemite Toad (Bufo canorus)

The Grinnell and Storer survey discovered the Yosemite Toad, and described it as a new species (Camp 1916, Grinnell and Storer 1924, p. 657). They found Yosemite Toads from Tamarack Flat and the ridges east of Chinquapin on the west, to Tioga Pass on the east. This species is a high elevation relative of the Western Toad, and Grinnell and Storer found it around lakes and streams from 2,040 m (Tamarack Flat) up to some of the highest elevations surveyed, including the head of Lyell Canyon (3,350 m) and Vogelsang Lake (3,150 m).

The general distribution of the Yosemite Toad has not changed appreciably since the 1920 survey. However in 1992, we found the species at only about half the sites where it was present in the earlier survey. Of the 13 survey sites where Grinnell and Storer recorded Yosemite Toads, we found the species at seven, ranging from Porcupine Flat on the west to Tioga Pass on the east. We also found a small number of Yosemite Toads at Evelyn Lake, which is not a site reported by Grinnell and Storer. This may or may not be a new location, however, as Grinnell and Storer only reported on this site incidental to their discussion of Vogelsang Lake; they did not give a complete accounting of this site.

At most of the sites where they were still present in 1992, the numbers of these toads were much lower. Grinnell and Storer's group found Yosemite Toads to be common at Mount Conness, Dingley Creek, and Lyell Glacier, and collected numbers of specimens at these sites (e.g. 17 at Lyell Glacier). We found single adults or subadults with small numbers of tadpoles at Dingley Creek and Lyell Glacier, and only tadpoles at Mount Conness. Kagarise Sherman and Morton (1993) report that toad numbers have declined steadily at Tioga Pass over the last 20 years. We searched Tioga Lake, Tioga Meadows, and upper Dana Meadows on three occasions in June and July of 1992. That year, Yosemite Toad tadpoles were only present in two small ponds near the south end of Tioga Lake, in spite of the presence of much good habitat in the area [1]. At the remaining sites with Yosemite Toads in 1992 (Porcupine Flat, Westfall Meadows, and Young Lakes), there were moderate to large numbers of tadpoles and there was no evident decline from the information reported by Grinnell and Storer.

Transformed individuals of Yosemite Toad were very scarce in 1992. We only found two adults - one at Westfall Meadows and one by a small pond in the head of Lyell Canyon. In addition, we found a total of fourteen newly transformed or subadult toads. Largest numbers of tadpoles were at Westfall Meadows and Elizabeth Lake (see Table 8, p. 32). We did not find eggs at any site, nor did we hear any calling adults over the course of the season.

We found Yosemite Toads in open meadows with low-growing sedge turf. Adults were out in the open around breeding ponds, while some of the subadult and newly transformed individuals were found under fallen trees and other cover. Most tadpoles were in very shallow sedge-filled pools and seeps. These ranged from five cm deep to less than one cm deep, barely enough to cover the tadpoles. A small group of tadpoles in a 1.6

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1. Grinnell and Storer only reported the presence of Yosemite Toad at Tioga Meadows; they did not provide information on numbers so, in spite of the very low numbers we found, we recorded this site as "no change" between the 1920 and 1992 surveys.

ha unnamed lake 1.3 km E of Evelyn Lake was in the broad shallow margin of the lake, in moderately dense emergent *Carex*. At Evelyn Lake and Elizabeth Lake, tadpoles were in deeper (20 - 40 cm), silt-bottomed pools and slow-moving inlet streams at the margin of the main lake.

Pacific Treefrog (Pseudacris regilla)

Grinnell and Storer found Pacific Treefrogs distributed throughout the Yosemite section, from Snelling at the edge of the Central Valley east to Walker Lake on the east side of the mountains, and up to 3,230 m on Mt Conness. Perhaps because of its ubiquitous occurrence, the Grinnell and Storer team frequently only noted the presence of Pacific Treefrogs (particularly when specimens were collected), or described individuals or groups "singing" in unusual situations (e.g. at an ice-covered lake on Mt. Conness, or with snow all around). They referred to abundance in rather general terms. Nonetheless, it is clear that they found the species to be relatively numerous, particularly at mid- to high-elevations. Different members of the team described Pacific Treefrogs as "common in 'lakes'" in the Porcupine Flat area (Storer field notes, June 1915), and "numerous in the moist grassy spaces between the pines" east of Merced Lake (Taylor field notes, August 1915). They noted "many Hylas heard croaking" near the head of Snow Creek and also west of Yosemite Creek (Camp field notes, June and July 1915), "scores of half-grown Hylas" in a meadow in Yosemite Valley, "within 1/4 mile of the Sentinel Hotel" (Grinnell field notes, October 1914), and "numerous male *Hyla regilla*s" calling in the marshes in Yosemite Valley (Storer field notes, Feb 1916).

We found Pacific Treefrogs similarly widely distributed, except that we did not find the species at any of the eastern Sierra Nevada sites. Of the 22 sites where Grinnell and Storer reported this species, we found it at 16. We also found treefrogs at Hazel Green, McCarthy Ranch, and Tioga Pass (where they were not reported by Grinnell and Storer), so the total number of sites with treefrogs was 19 in 1992. It is possible that Grinnell and Storer found Pacific Treefrogs at these latter three sites, but simply did not bother to record them. However, we take the conservative course and consider Hazel Green, McCarthy Ranch, and Tioga Pass to be "new" sites.

Although still widely distributed, numbers of Pacific Treefrog were significantly reduced from the time of the Grinnell and Storer survey (Table 5). At half of the sites where Pacific Treefrog was present there was either no discernible change in abundance, or we were unable to judge because of insufficient information in Grinnell and Storer's notes. At the remaining sites, however, there was a clear decline in relative numbers at 11 of the 14 areas. Low numbers were particularly conspicuous at some areas such as Yosemite Valley and Crane Flat that had large areas of good habitat but few or no frogs.

It has been noted that there appears to be a greater tendency toward declines among high-elevation amphibian species (Wake 1991). For this reason, we divided the data for Pacific Treefrog into low-elevation sites (< 1500 m, up to and including Yosemite Valley) and high elevation sites (> 1500 m, Merced Grove, Chinquapin, and above), to assess whether population trends differed with respect to elevation (Table 5). There was no apparent trend at the nine low elevation sites, with apparent increases from 1920 to 1992 at two sites, decreases at three sites, and no evident change at the remaining sites. At the 16 high elevation sites, there was a significant trend ($p = 0.02$, Sign Test) toward decreased populations. Of the 16 sites, declines from 1920 to 1992 were noted at eight sites, with a possible increase at only one site.

Pacific Treefrogs were present in a variety of habitats. Adults were primarily found in wet meadows adjacent to or in breeding pools. We found a few adults active in dry areas of meadows, in woodlands adjacent to streams and meadows, and hiding under logs and other ground cover. Tadpoles were present in a wide variety of habitats including small, shaded, slow-moving streams, marshy margins of large lakes such as Merced Lake, small temporary ponds as small as 3 x 5 m and 5 cm deep, and larger, permanent or semipermanent ponds up to 100 m across or more. In the few instances where they were present in large lakes with fish (e.g. Babcock Lake, Dog Lake, and Merced Lake), they were confined to shallows with dense emergent vegetation.

Red-legged Frog (Rana aurora)

The Red-legged Frog is primarily a frog of the lowlands, in marshes, ponds, and slow-moving streams. The Grinnell and Storer survey found this species at three sites at the west end of the transect: Snelling, McCarthy Ranch, and Smith Creek. They referred to it variously as *Rana draytoni*, the "big striped frog," and the "French frog." Their only reference to abundance of the species is "not common" at Smith Creek (Storer field notes, June 1915).

This species was not present in the rivers, streams and ponds of Snelling, McCarthy Ranch, and Smith Creek in 1992. We did find Red-legged Frogs at one site in the survey area, away from any of the Grinnell and Storer sites. This was in Cuneo Creek, on a ranch along the Priest-Coulterville Road 0.8 km N of Mariposa County Highway J20. Here, a few hundred tadpoles of this species were present in a small, turbid pond backed up by a concrete dam along the creek. No other tadpoles nor adults of this species were seen in the small stream above and below the dam. Several adult bullfrogs (*Rana catesbeiana*) were present in the portion of the stream draining into the pond. This co-occurrence is unusual; bullfrogs are commonly cited as leading to the elimination of red-legged frogs where the two species occur together (e.g. Moyle 1973; extensive review in Hayes and Jennings 1986).

Foothill Yellow-legged Frog (Rana boylii)

At the time of the Grinnell and Storer survey, the two yellow-legged frog species were treated as subspecies: the "California yellow-legged frog," *Rana boylii boylii* (= *R. boylii*); and the "Sierra yellow-legged frog," *R. boylii sierrae* (= *R. muscosa*). Grinnell and Storer found what is now recognized as the Foothill Yellow-legged Frog in the western foothill portion of the transect, from Piney Creek and Pleasant Valley east to Sweetwater Creek, near Feliciana Mountain. They also reported this species at the eastern end of the transect, at Farrington Ranch near Mono Lake, but this probably represents a misidentification of Mountain Yellow-legged Frogs. Except for the Grinnell report, Foothill Yellow-legged Frogs are not known from sites east of the Sierra Nevada. Mountain Yellow-legged Frogs, on the other hand, have been reported from other areas at the edge of the high desert east of the Sierran crest (R. Knapp, pers. comm.). Although Grinnell and Storer did not find Foothill Yellow-legged Frogs within the boundaries of Yosemite National Park, later observations and collections did establish its presence there - along Eleanor Creek at the base of Lake Eleanor dam, at Fern Springs within Yosemite Valley, and at Wawona (Martin 1940, Richards 1958).

Considering the foothill and mountain species together, Grinnell and Storer described the yellow-legged frog as "the commonest amphibian in most parts of the Yosemite section." The foothill species (the currently recognized *R. boylii*) apparently did not reach the very high numbers seen for Mountain Yellow-legged Frog. Specific references include "fairly common" along Smith Creek (Storer field notes, June 1915), "moderate numbers" along Blacks Creek (Storer field notes, May 1916), and "several" along Piney Creek (Camp field notes, May 1915). Nonetheless, the discussion in Grinnell and Storer (1924) and the field notes of the Grinnell and Storer team indicate that Foothill Yellow-legged Frogs were formerly widespread and common.

In spite of thorough searches for tadpoles and adults, in habitat that appeared suitable, we failed to find Foothill Yellow-legged Frogs at any of the sites where Grinnell and Storer found this species. Both in 1992 and again in 1993, we searched other streams that offered suitable habitat for Foothill Yellow-legged Frogs in the elevational range where Grinnell and Storer found the species. These additional sites included a number of areas where Foothill Yellow-legged Frog had definitely been recorded in the past, including the sites within Yosemite National Park noted above, and sites where the 1924 Lyell Canyon expedition found the species in tributaries of the Merced River below El Portal (J. R. Slevin / Lyell Canyon Expedition collections at the California Academy of Sciences). At none of these sites did we find any individuals of the Foothill Yellow-legged Frog.

Grinnell and Storer reported the habitat of Foothill Yellow-legged Frogs in the Yosemite area as slow-moving streams with outcropping rocks in the Upper Sonoran and Transition zone.

Mountain Yellow-legged Frog (Rana muscosa)

At the time of the 1920 survey, this species (= *Rana boylii sierrae* of Grinnell and Storer) was abundant in lakes and streams throughout the high-elevation portion of the Yosemite transect, from Westfall Meadows and Porcupine Flat east to the head of Lyell Canyon and Tioga Pass. There was also an apparent disjunct population at Farrington Ranch on the east side of the mountains (see note under Foothill Yellow-legged Frog, above). The Grinnell and Storer account describes Mountain Yellow-legged Frogs as the most abundant amphibian along the Yosemite Section. Their field notes describe "hundreds of frogs" at Young Lake (Camp field notes, July 1915), and "very numerous" at Westfall Meadow (Camp field notes, June 1915). They also collected large numbers of specimens - for example 25 taken at Vogelsang Lake (Grinnell field notes, August 1915)

In 1992, Mountain Yellow-legged Frogs had essentially disappeared from the transect sites. We only found the species at two of the Grinnell and Storer locations: at Mono Meadow a single tadpole was captured in a dip net; and at Evelyn Lake, a single adult female was captured on two separate dates along the outflow stream of the lake. At Mono Meadows, the presence of the tadpole indicates the persistence of at least a very small breeding population. However, thorough searches of Evelyn Lake, its inlet and outlet streams, and nearby ponds and overflow pools on July 7 and August 5 found only the single frog (presumably the same individual, distinctively marked and caught in the same general area on both dates). We found no other adults, tadpoles, or eggs.

We found Mountain Yellow-legged Frogs at a few sites along the Yosemite transect away from the Grinnell and Storer sites. These were: 1) a single adult male that was captured and released at the "G7" meadow along the Glacier Point Road; 2) a small population at Summit Meadow along the Glacier Point Road, where 16 - 18 adults and 30 tadpoles were counted in June; and 3) at Mount Hoffmann, where we counted 113 tadpoles in an isolated glacial tarn at 3,070 m elevation, on the west side of the granite ridge west of May Lake. Though relatively few in number, the frogs at Summit Meadow and Mount Hoffmann appear to viable populations. As with Evelyn Lake, however, the single frog at the G7 Meadow appears to be a relict individual.

The few populations of Mountain Yellow-legged Frog found during this survey occurred in very different habitats. The adults and larvae at Summit Meadow were in a small wet meadow with a meandering, silt-bottomed stream and two medium-sized boggy ponds. The tadpoles at Mount Hoffmann were in a pair of deep, narrow, boulder-filled glacial ponds, 120 m x 30 m and 300 m x 50 m. The surrounding area was bare granite boulder piles and bedrock. The single adult at Evelyn Lake was along the banks of the outlet stream of the lake, and in the immediately adjacent overflow pools, 200 m downstream from the lake. The stream banks and the bench surrounding Evelyn Lake are open meadow, and there are scattered willows along the outlet stream.

Bullfrog (Rana catesbeiana)

The bullfrog is a large ranid frog native to eastern and central North America. It was introduced into the San Francisco Bay area of California in the late 1800's (Jennings and Hayes 1985) and has subsequently spread and been distributed into other areas around the state. It apparently had not yet reached the survey area by 1920, as it is a very conspicuous species and was not reported by Grinnell and Storer. Bullfrogs were introduced into the ponds around the Ahwahnee Hotel in Yosemite Valley sometime after this; they were recorded within the Valley in the list compiled in 1955 by Richards (1958).

We found bullfrogs to be common to abundant in suitable habitats in the foothill sites at the west end of the transect, including LaGrange, Snelling, and McCarthy Ranch. They were also present in moderate numbers at the two Yosemite Valley sites. In the Valley, we found them in a moderate-sized pond on the east side of the confluence of Indian Canyon Creek and the Merced River, and in overflow ponds along the Merced River at Leidig Meadow, as well as at the ponds at the Ahwahnee Hotel. In the survey area, bullfrogs occurred in open, silt-bottomed ponds, river backwaters, and overflow pools along rivers. We did not find them in smaller, faster-flowing streams, nor did we find them in the shade of woodland canopies.

Great Basin Spadefoot (*Scaphiopus intermontanus*)

Grinnell and Storer recorded this species (as *Scaphiopus hammondii*) at three of the easternmost survey sites of the transect: Farrington Ranch; Mono Lake; and Mono Mills (our Dry Creek). Three spadefoot toads were captured incidentally in small mammal traps set around Farrington Ranch in early May 1916, and two more specimens were taken at Mono Mills on June 20, 1916, in the same manner. They caught one additional specimen by hand near the southwest shore of Mono Lake, during a thunderstorm on July 22, 1915.

We did not find any Spadefoot Toads during our surveys, though we searched all three of the areas where Grinnell and Storer found the species. The Farrington Ranch site is rolling pasture, with some low-lying areas along Walker Creek. The creek in this area is broad and fast-flowing and contains trout. There are large areas of wet meadow along the creek, but we did not find any ponded areas that appeared to offer suitable habitat for breeding spadefoots. We searched vernal ponds and marshes along the west and southwest shore of Mono Lake, and along Dry Creek at State Highway 120, but did not find the species at these sites, either.

Grinnell and Storer report the habitat of this species as "sandy situations" in the Transition Zone in the vicinity of Mono Lake. They note the relationship of breeding activity in these toads to summer rains, and report that females they collected between May 5 and June 20 were in breeding condition.

Discussion

Seriousness of Decline

The decline of native frog species along the Yosemite transect is alarming in both its extent and its magnitude. The trend for all species is downward, in some cases sharply so. Previous reports of frog declines have focused on individual species or groups of species. Documentation of an entire frog fauna declining throughout a region is unprecedented. The size of the area surveyed spans a linear distance of over 140 km, and includes habitats ranging from foothill oak savanna through coniferous forest to alpine fell-fields to high desert. Species involved range from ranid frogs closely tied to waters of lakes and streams, to toads adapted to drier conditions and breeding in temporary ponds and wet meadows, to the treefrog, which occurs in a wide range of habitats and breeds in a similarly wide variety of water bodies.

Individual Species

The decline has been most severe among the ranid frogs. One species - Foothill Yellow-legged Frog - has apparently disappeared from the area entirely. We were unable to find any evidence of it either at the sites where Grinnell and Storer found it during their surveys, or at other areas of suitable habitat that we checked. At the time of Grinnell and Storer's survey, both adults and tadpoles were common in streams throughout the western portion of the transect. Between 1976 and 1980, Lawrence Cory and David Graber searched sites throughout the Yosemite foothills and south to the area of Sequoia and Kings Canyon National Parks that had formerly supported Foothill Yellow-legged Frogs, but failed to find the species (D. Graber, Sequoia and Kings Canyon National Parks, pers. comm.; L. Cory, St. Mary's College, Moraga, CA); it appears that the Foothill Yellow-legged Frog may now be extirpated in the southern Sierra Nevada.

A decline almost equally drastic has occurred in the closely related Mountain Yellow-legged Frog. We were only able to find two individuals of this species - one tadpole and one adult - at any of the Grinnell and Storer sites. Taken together, the two species of yellow-legged frog were described by Grinnell and Storer as "the commonest amphibian in most parts of the Yosemite section . . . its numbers, especially at the higher altitudes, far exceed those of the (Pacific Treefrog)." Hence, of two of the most common frog species during Grinnell and Storer's survey, one has disappeared entirely and the other has gone from being the most abundant species to one of the rarest. We did find apparently viable populations of Mountain Yellow-legged Frogs at some sites not checked by Grinnell and Storer, but even so, these groups were very small and widely-separated. The decline of the Mountain Yellow-legged Frog is one of the most significant animal population changes in the Yosemite region in historic times, on the same scale as the loss of the Grizzly Bear from the entire California region.

The formerly common and numerous Western Toad also appears to have suffered a serious decline in the Yosemite area. Grinnell and Storer described Western Toads as "exceedingly abundant" at foothill localities in the western part of the survey area. In the 1992 survey, we only found Western Toads at one of the six sites where Grinnell and Storer recorded it, and even at this site (Yosemite Valley), we found few individuals. Both Western and Yosemite Toads are moderately cryptic, and they resort to underground retreats during dry conditions. However the very low numbers we found, over the entire course of the season, together with low numbers of eggs and tadpoles at the few breeding sites encountered, indicate that the decline is both real and serious. Large declines of Western Toad have been reported from many areas in the Rocky Mountains (Carey 1993, Corn and Bury 1992), the Yellowstone - Grand Teton area (Peterson et al., in press) and the Oregon Cascades (Blaustein and Olson 1991), but this is the first report we know of for the Sierra Nevada.

The Grinnell and Storer survey found Yosemite Toads at many of their high-elevation sites and reported conspicuous choruses. We found Yosemite Toads at only about half of the sites where Grinnell and Storer found them, and in very low numbers at most sites. In addition, most of our records are of tadpoles, which Grinnell and Storer did not take note of. Considering only transformed individuals, we found this species at only five of the 13 sites where Grinnell and Storer recorded it (38%). Even at these five sites, Yosemite Toad numbers were lower at at least two of the sites, so that the species has declined or disappeared from at least 70% of the locations reported by Grinnell and Storer. These declines parallel trends reported for other areas in the southern and central Sierra Nevada, where the species has been reported to be "extinct" at 47% of historical localities (Martin 1991a, 1991b).

The Red-legged Frog is a lowland species that ranges into the foothills at the western end of the transect. This species has declined throughout much of its range in California (Moyle 1973, Hayes and Jennings 1986), and this trend was reflected in our surveys. We found Red-legged Frog tadpoles in a single, small, man-made pond along Cuneo Creek near Coulterville. We did not find the species at any of the Grinnell and Storer sites, nor at any other area surveyed.

We returned to the Cuneo Creek site in 1993 and searched the area again. This year we found neither tadpoles nor transformed frogs at the site, so it is possible that this small population has also disappeared. We did not find any additional populations of Red-legged Frogs in the Yosemite area during the 1993 surveys.

Like the Red-legged Frog, the Great Basin Spadefoot only ranges into the edge of the survey area. Grinnell and Storer found this species at Farrington Ranch, Mono Lake, and Mono Mills on the east end of the transect. We did not find Spadefoot Toads at any of the sites checked. However, this species is the most difficult of any of the frogs along the transect to find. It burrows underground during the long dry periods in the desert, emerging after summer rains to breed in temporary pools. We consider our results for the Great Basin Spadefoot to be the only "question mark" in our survey of the frog species along the Yosemite transect. Our failure to find this species at the few sites where Grinnell and Storer found it cannot be taken as strong evidence of a population decline, but it does highlight the need for more intensive surveys to establish the status of this species. There is little information on population trends for Spadefoot Toads anywhere within their range.

The Pacific Treefrog is a widespread species that occurs abundantly in a wide variety of habitats. Grinnell and Storer found it at the majority of stations along the entire length of the transect, from the low oak grasslands at Snelling, to alpine lakes on Mt. Conness, to the dry east slope of the mountains at Walker Lake. Our surveys found Pacific Treefrogs to be nearly as widespread as at the time of Grinnell and Storer's survey, with the species present at sites ranging from Snelling to Tioga Pass. Comparing relative abundance between 1920 and 1992, however, there was a significant decline across the sites surveyed. Based on a survey of 75 sites in the Sierra Nevada that he conducted in 1990, Martin (1991b) also noted that Pacific Treefrog numbers appeared to be significantly lower than 10 years previously. Except for this observation, a general pattern of decline has not previously been reported for Pacific Treefrog, so it is not clear whether this is a widespread or long-term trend (cf. Pechmann et al. 1991). Added to the serious declines seen in other species in the region, however, it is a serious source of concern that should be further investigated.

In addition to our site by site comparisons, there are other indications that Pacific Treefrog populations are faring poorly. Several large areas of good habitat had very few frogs. The meadow areas on either side of the road at Crane Flat were searched on 3 occasions, and no adult frogs or tadpoles were found. Likewise, large areas of wet meadow in Yosemite Valley, Tuolumne Meadows, Tioga Pass, and other areas had many good pools and marshes for breeding. However, they were nearly devoid of Pacific Treefrog, with numbers of tadpoles ranging from less than 100 to 200 and 300 (Table 6). Also, we heard very few breeding choruses of Pacific Treefrog. We were in the field for 28 days during the period May 11 to September 11, including 17 evenings. We spent time at locations from El Portal to Tioga Pass specifically listening for frog choruses. Over the course of the summer, small numbers of calling frogs were heard on only 7 occasions.

When we divided our data into high-elevation (> 1500 m) and low-elevation sites, there was a significant trend toward decreased numbers of Pacific Treefrog at high elevations but no apparent trend at low elevations (Table 5). At high elevations, very few adult frogs were seen or heard, and tadpoles were widely scattered, being absent from many apparently suitable sites, and present in low numbers at other sites (Table 7).

Table 6. Numbers of Pacific Treefrog tadpoles in some of the meadow systems of Yosemite National Park. Smaller meadows (Crane Flat, G7, Peregoy, and Summit) were searched in their entirety. Selected parts of the larger meadows were surveyed - generally those that appeared to offer the best habitat. Appendix 2 lists date and amount of time spent searching each area, along with notes on the site.

Area	Dates	Total # of tadpoles
Crane Flat	May 13, June 9	0
G-7 [1]	Sept 9	25
Mono Meadow	June 9	200
Peregoy Meadow	June 9	15
Summit Meadow	June 9, July 2, Sept 9	200
Tioga Pass	June 9 & 11, July 15	200
Tuolumne Meadows	June 9 & 11, July 3	350
Yosemite Valley	May 13 & 14, Sept 11	50-70

1. Unnamed meadow at the G7 roadside marker along the Glacier Point Road.

Table 7. Distribution and numbers of Pacific Treefrog tadpoles in mid- and high-elevation ponds and lakes in Yosemite National Park. Enumerated ponds include those that were specifically searched for Pacific Treefrog and that were judged to provide suitable conditions for breeding (see text).

	Number of Ponds		
Area	Total	# with Pacific Treefrog	Total # of tadpoles
Dog Lake	4	4	5500
Lyell Fork [1]	36	4	175
McGee Lake	1	1	75
Medlicott Dome [2]	2	2	23
Mirror Lake	2	0	0
Mount Conness	12	0	0
Mount Hoffmann	5	3	2700
Ten Lakes	8	4	660
Tenaya Lake [3]	1	1	4
Vogelsang Lake Loop [4]	25	10	ca 1400
	96	29	ca 10,500

1. Includes Lyell Fork upstream from Tuolumne Meadows trailhead, Maclure Creek and other streams draining Lyell Glacier, Ireland Lake, Evelyn Lake, and nearby potholes and marshes.

2. Plus 9 dead newly-transformed frogs.

3. Small pond 2.6 mi E of E end of Tenaya Lake, on N side of Tioga Road.

4. John Muir trail from Tuolumne Meadows to Ireland Creek to Vogelsang Lake to Merced Lake to Little Yosemite Valley.

A general pattern of high-elevation frog species declining has been tentatively reported (Wake 1991), and has been taken as evidence for some global scale hypotheses for amphibian declines. However this is the first documented instance of a wide-ranging species that may be declining at high elevations but not at lower elevations, and this lends weight to speculation about a causal link between elevational range and decline.

POSSIBLE CAUSES OF DECLINE

The extent of the decline, both geographically and in terms of the variety of species affected, the magnitude of the loss, and its apparent coincidence in time among the different species, suggests a strong, pervasive force or forces affecting the frog fauna in the Yosemite region. A variety of hypotheses have been set forth for worldwide amphibian declines (see Blaustein and Wake 1990 and Wyman 1990 for reviews). Some of these are known to be affecting frog species in the Yosemite area, others may be having an effect, and still others are clearly not important. We discuss potential causes for the declines in the Yosemite region below. Factors such as introduced predatory fish have definitely affected frog distribution and numbers; for some frog species and in some areas these effects have been severe. We cannot, however, determine whether any one factor or combination of factors accounts for the full magnitude and extent of the decline, nor can we say that all possible adverse forces affecting the frogs have been identified. In the Yosemite area, as elsewhere, the declines are very much an enigma and their cause is sorely in need of further study.

1. Introduced fish

It has long been noted that frogs generally do not occur in waters where fish have been introduced, presumably due to the fish preying on tadpoles and small frogs (Grinnell and Storer 1924, Cory 1963, Liss and Larson 1991). Field surveys of ranid frogs in the western United States have consistently demonstrated reduced numbers or complete absence of frogs in waters with fish (e.g. Hayes and Jennings 1986, Bradford 1989) and experimental studies have shown reduction or elimination of amphibian populations following introductions of fish (Sexton and Phillips 1986). More recent studies have hypothesized that introduced fish in streams and other permanent waters may effectively restrict frog populations to isolated areas of fish-free habitat. Such small, isolated populations may be more likely to die out (e.g. Bradford 1991), and the presence of fish in intervening streams and ponds may prevent dispersing frogs from moving back to recolonize such sites when a local population does disappear (Bradford et al. 1991a, Bradford et al. 1993).

Widespread introduction of fish has evidently limited the distribution and overall numbers of some frog species, particularly Mountain Yellow-legged Frogs. It does not seem to adequately explain the overall decline of the frog fauna in the Yosemite area, however, for several reasons. First, most or all of the frog species in the area are capable of surviving and reproducing in waters containing fish, as long as there is emergent vegetation or other escape cover present (e.g. Cory 1963; we have also noted this in our Yosemite surveys and during earlier studies at Lassen Volcanic National Park). The Mountain Yellow-legged Frog seems to be most susceptible to fish predation, yet it remained the most numerous frog species in Westfall Meadows as late as 1977, long after fish were introduced (Yoon 1977). It has since disappeared from that area.

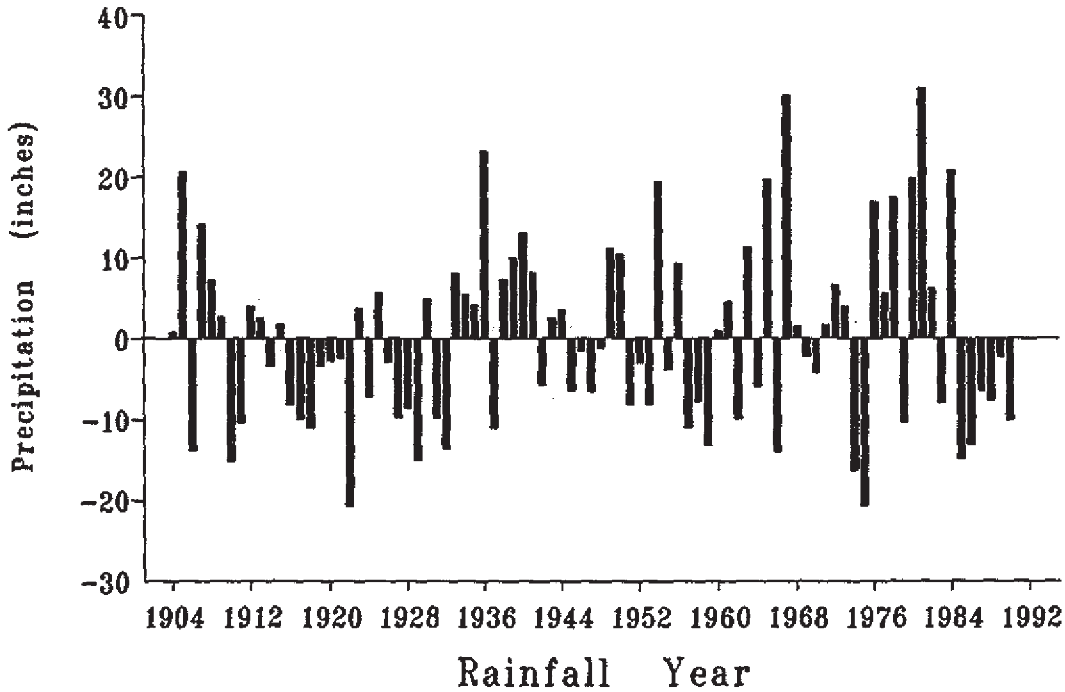
The toad species are much less susceptible to adverse effects of introduced fish, for two reasons: 1) both the true toads (Western and Yosemite) and the Spadefoot Toads frequently breed in ephemeral bodies of water that do not harbor fish; and 2) the true toads produce toxic skin secretions, and fish and other predators tend to avoid them (see e.g. Peterson and Blaustein 1991).

In addition, frog populations have disappeared from sites that either were never planted with fish, or that are too small or ephemeral to support fish. For example, Tuolumne Meadows and the Tioga Pass area contain extensive meadow pools and marshes that are effectively isolated from streams and lakes supporting fish. Yosemite Toads and Mountain Yellow-legged Frogs formerly occurred in both of these areas (Grinnell and Storer 1924; Lyell Canyon Expedition collection data, California Academy of Sciences); Mountain Yellow-legged Frogs have disappeared from these areas entirely, while Yosemite Toads have disappeared from Tuolumne Meadows, and have dwindled to a remnant population at Tioga Pass. Finally, what is known of the timing of the population declines does not agree with introduced fish being the sole or primary cause. Large numbers of trout were planted in Yosemite National Park waters between 1932 and 1951, with peaks of over 1,000,000 fish per year in the late 1930's and 1940's. Since 1951, the number of fish planted has steadily declined (Elliot and Loughlin 1993). Significant declines for Yosemite Toad, Mountain Yellow-legged Frog, and probably other species seem to have come much later than this - in the 1970's and later.

2. Drought

Over the period 1987 to 1992, California has experienced a severe drought. This drought has lasted unusually long and, based on both its length and the year-by-year precipitation totals, it is the most severe drought on record in the San Joaquin River watershed (Figure 2). Based on the historical runoff record, it has been estimated that the 1987-1992 period represents an approximately 1-in-300 year drought event (Roos 1992).

Figure 2. Rainfall measured at Yosemite Valley from 1904 through 1992. The graph shows departure from the mean over this period (x = 35.48 in. (90.12 cm)). Positive values on the graph indicate greater than average precipitation and negative values indicate less than average precipitation. Years shown are "rainfall years" extending from July 1 of one year through June 30 of the next (e.g. rainfall year 1905 on the graph extends from July 1, 1905 through June 30, 1906).



This protracted drought has obviously had some adverse effects on frog populations in the area. Some mapped ponds that we visited during the 1992 survey had dried up entirely, and some meadow areas were evidently very dry. Such dry periods probably have the most severe effect on amphibians that are closely associated with water throughout their entire life cycle, and those that have multi-year aquatic larval stages, such as the Mountain Yellow-legged Frog. However, such droughts presumably also have a negative effect on species such as toads that are adapted to drier conditions and are able to make use of ephemeral breeding sites.

Nonetheless, it is unlikely that the drought has had more than an exacerbating effect on the observed declines. All of California, including the Sierra Nevada region, is subject to periodic droughts and most plants and animals living here are adapted to lengthy dry periods. The Grinnell and Storer survey also occurred during a drought period (Figure 2), so comparisons between our surveys should not be unduly biased in this regard. Yoon (1977) reported that Mountain Yellow-legged Frogs were still common in Westfall Meadow in 1977, at the end of a drought that was shorter than the present one, but had much lower annual rainfall totals (see Figure 2). As already noted, this species disappeared from Westfall Meadows sometime since 1977. Finally, the declines of the Yosemite Toad, Red-legged Frog, Foothill Yellow-legged Frog and possibly Mountain Yellow-legged Frog seem to have been going on for 15 or 20 years (e.g. Bradford et al (ms.), Moyle 1973, Kagarise Sherman and Morton 1993). Excepting the current drought, most of this period has been wetter than normal.

3. Acid precipitation

"Acid rain" effects on living organisms have been a subject of concern and study since the early 1970's (e.g. Charles 1991, Hutchinson and Havas 1980). Increased acidity in ponds and lakes has been shown to adversely affect a variety of sensitive aquatic organisms. There have been documented declines in breeding amphibian populations in parts of the United States and Europe due to acidified waters (Beebee et al. 1990, Freda and Dunson 1985, Pough 1976, Wyman 1990; see also Harte and Hoffman 1989). Low pH values may kill amphibian eggs outright or may result in abnormal embryonic development (Gosner and Black 1957).

Recent reports indicate there is a high potential for damage from acid precipitation in the state of California. This includes harm to lakes in the Sierra Nevada, which are very susceptible to acidification because of their low acid neutralizing capacity. Because of the rainfall pattern in the Sierra Nevada, acid pollutants are deposited both intermittently, during snowmelt and summer thunderstorms, and also more or less continuously in the form of dry particulates. Dry deposition accounts for the majority of acidic deposition in southern California (CARB 1988).

Although they do not yet show chronic acidification, high-elevation lakes that are being monitored in the Sierra Nevada may become temporarily acidified during snowmelt and following summer storms. Mean pH values measured for precipitation in the Sierra Nevada range from 5.2 to 5.5 (CARB 1988). This increased acidity is sufficient to kill sensitive zooplankton and aquatic macroinvertebrates, however this does not appear to have caused broad scale effects on distribution of these invertebrate species (Melack and Stoddard 1991). Laboratory tests indicate Sierran frogs do not suffer significantly increased mortality until pH drops below 4.7, though when aluminum ions are present in the water, measures of development (hatching time and growth rate) for some species showed significant negative changes at a pH as high as 5.2 to 5.8 (Bradford and Gordon 1992). In a field study of lakes throughout the Sierra Nevada, Bradford and Gordon (1992) found no significant relationship between pH and related water chemistry parameters and amphibian presence or absence, nor between pH and amphibian species composition in breeding sites. They concluded that acid deposition was unlikely to be the cause of amphibian declines in the Sierra Nevada.

In spite of careful laboratory studies on increased acidity effects on Sierra Nevada frogs, the effects of increased acidity in natural systems deserves further study. Indirect or compounded effects may be important under such conditions. For example, some recent hypotheses have suggested that heightened environmental stresses may lead to increased susceptibility to severe disease outbreaks (Carey 1993). Surface water acidification should not be discounted in ongoing investigations of the cause of amphibian population declines.

4. Pesticides

Insecticides and other toxic chemicals may kill adult and larval amphibians (e.g. Johnson and Prine 1976, Porter and Hakanson 1976). Other forms of pollution such as heavy metals have been suggested as a cause of amphibian declines (Hayes and Jennings 1986, Wake 1991). However, direct introduction of pesticides and other pollutants does not seem to be a significant problem in the vicinity of the Yosemite transect, particularly within Yosemite National Park. Except for limited aerial spraying of Malathion to control lodgepole needle miners in 1959-1963 (Yosemite National Park 1985), and some limited use of DDT over 20 years ago (documented by L. Cory, J. van Wagtendonk, pers. comm.) there has been very little use of toxic chemicals within the Park.

A more likely source of toxic chemicals entering the environment is broad-scale pesticide drift from the intense agriculture practiced in the San Joaquin Valley west of the Sierra Nevada. Recent studies (Zabik and Seiber 1993) have shown that organophosphate insecticides used in the valley are transported in measurable quantities to over 1900 m in the mountains, with heaviest concentrations reaching the ground in rain water during the winter. However, direct toxicological studies of these agricultural chemicals on amphibians are lacking. For local populations of amphibians in the Sierra Nevada, this represents the greatest information gap in determining the cause of observed population declines.

5. Ultraviolet light

Increased levels of ultraviolet light, due to thinning of the upper atmosphere ozone layer, have also been suggested as a cause of worldwide amphibian declines (Wake 1991, Wyman 1990). In addition to extensive evidence of upper atmosphere ozone depletion (e.g. Kerr 1988), this hypothesis follows on other observations about the decline, including: 1) its apparent global extent; 2) the comparatively recent and sudden onset of many of the declines, and the correlation in the timing of the declines among a wide variety of species; and 3) a putative trend toward more severe effects upon high-elevation species, such as the Mountain Yellow-legged Frog and Yosemite Toad in our area (Wake 1991). High-elevation populations of amphibians have adaptations to protect against intense ultraviolet radiation, such as dense concentrations of melanin in their eggs and reproductive organs, but it is possible that they are near their physiological limits of exposure at current ultraviolet radiation levels. The disparate tendency toward declines in high-elevation populations of the Pacific Treefrog is the first documented instance of differential population changes for a frog species with a wide elevational distribution, and is indirect but suggestive evidence that some broad-scale phenomenon such as increased ultraviolet light may be involved in the amphibian declines.

There is no direct evidence of increased ultraviolet radiation causing the decline of amphibian species. Increased UV radiation does have a deleterious effect on animals (e.g. Bullock 1982, Urbach 1969) and amphibians are particularly vulnerable because of their relatively unprotective integument. Recent field experiments by Blaustein (in prep.) demonstrate that ambient UV levels at earth surface are capable of causing increased mortality and reduced reproductive success. Arguing against any effect of increased UV is the fact that chronically elevated ultraviolet levels have only been reported from a few areas of the world. On the other hand, earth-surface measurements of ultraviolet radiation are not extensive, available data are in some cases ambiguous, and additional monitoring is needed to understand both spatial and temporal patterns of UV reaching the earth's surface (e.g. WHO 1979). Also, as already discussed, some studies have postulated that added environmental stresses may result in breakdown of immune function, leading to large die-offs from "normal" mortality sources, such as disease (there is recent evidence of ultraviolet radiation causing decreased immune function - see Kripke 1989, Longstreth 1990 - and massive die-offs from disease in Western Toads in the southern Rockies have been attributed to stress-caused failure of the immune system - see Carey 1993). The evidence for an influence from ultraviolet radiation remains speculative and circumstantial, but until compelling evidence is brought forth for some other cause, this hypothesis must be considered an important possibility.

Management Recommendations

Most of the frogs in the Yosemite area have suffered serious population declines. One species has disappeared completely, while others have been reduced to very low numbers; if apparent trends continue, some of these species will be lost as well. Intensive research into the amphibian losses and concerted management efforts are urgently needed. Listed in priority order, these research and management needs include:

1. close monitoring of surviving populations;

2. extensive surveys for viable populations of all species;

3. intensive research into the cause or causes of the declines;

4. pilot studies to eliminate introduced predators of native amphibians (fish and bullfrogs);

5. carefully conducted reintroduction projects for species that have been extirpated; and

6. review population status of area amphibians, and work toward official protected status for those species that require it.

The following paragraphs discuss these research and management recommendations for amphibian populations within Yosemite National Park. A three-year study of the declining amphibian problem in the Western Region is being directed by Dr. Gary Fellers, and will focus in part on the losses in Yosemite. This work should accomplish some of the goals listed. Other parts of the recommendations may be best carried out by Yosemite National Park personnel, either in conjunction with existing work or as new studies or management efforts. Due to the wide scale of the amphibian declines, cooperation with other concerned state and federal agencies, including the California Department of Fish and Game, California Air Resources Board, the National Biological Survey, U. S. Environmental Protection Agency, U. S. Fish and Wildlife Service, and U. S. Forest Service, is warranted.

1. MONITORING OF SURVIVING POPULATIONS

Continued monitoring of known populations is critically needed to assess present trends in those populations, and also to gain information about what may be causing the declines. Some areas surveyed during 1992 had only one or a few individuals present - for example, we found single individuals of Mountain Yellow-legged Frogs at Evelyn Lake and the G7 Meadow. We know that both Evelyn Lake and the G7 area supported sizable populations of Yellow-legged Frogs at one time, and these few individuals are apparently the last remnants of those local populations that will disappear completely within the next few years [see Fellers and Drost (1993) for an account of a similar extirpation in the Lassen

National Park area]. Other sites had small to moderate-sized populations (e.g. 40 - 50 individuals). We do not know if these small populations are still declining or whether they have stabilized and may persist at their present level. Year-to-year monitoring is required to assess the trends in these surviving populations. Careful monitoring may also provide some of the best information on the cause of the declines, as discussed below.

For purposes of determining population trend over a period of years, two or three surveys of the population in the spring and summer (after ice-melt at the higher elevations) is sufficient. For intensive monitoring to evaluate mortality sources, reproductive success, and possible causes of population declines, the site should be surveyed at least once every two weeks. Population information recorded at each site should include numbers of adults and subadults, breeding activity, numbers of eggs, larvae, and transforming individuals, and any indications of mortality, poor condition, or abnormal behavior. Suggested sites for monitoring, drawn from the 1992 fieldwork, are listed in Table 8.

2. Further Surveys for Viable Amphibian Populations

Intensive year-to-year monitoring of known populations should be coupled with continued surveys of other areas of the Park and surrounding lands, to locate additional populations of all of the amphibian species discussed here. Such surveys will serve a number of purposes: 1) they will provide additional information on the spatial pattern of the decline, which may be important in understanding its cause or its future progress; 2) anticipating larger-scale reintroduction efforts, new sites found will provide additional potential source populations, as well as (potentially) providing a greater range of genetic variability for restoration purposes; 3) the surveys will form a stronger basis for evaluating the overall status of each of the amphibian species in the area, allowing for better protection and management efforts. These surveys might include encouragement of observations from Yosemite National Park personnel who are stationed in the field, along with systematic sampling by dedicated field crews. This system has worked well for similar surveys at Sequoia and Kings Canyon National Parks (D. Graber, Sequoia and Kings Canyon National Parks, pers. comm.). A detailed discussion of further survey work for amphibians in the Yosemite area is given by Fellers (1993).

3. Cause of Declines

Ultimately, the most pressing demand is for careful study of what is causing the declines. For some species, factors contributing to long-term population declines are known. For instance, non-native predatory fish have reduced the distribution and numbers of some ranid frogs, especially the Mountain Yellow-legged Frog (e.g. Bradford 1989, Grinnell and Storer 1924). As with other hypothesized causes, however, introduced fish do

Table 8. Largest populations of Yosemite Toad and Mountain Yellow-legged Frog found during the 1992 survey of the 'Yosemite section.' These sites would be good candidates for long-term monitoring of these populations. Details on exact location of the sites, and of the amphibians recorded at each site in 1992, are given in Appendices 1 and 2, respectively.

	Numbers
Yosemite Toad	
Westfall Meadows	10,000 tadpoles
Elizabeth Lake	2,000 tadpoles
Young Lakes	1,200 tadpoles + 3 juveniles
Porcupine Flat	450 tadpoles + 7 juveniles
Tioga Pass	350 tadpoles
Mountain Yellow-legged Frog	
Mount Hoffmann	113 tadpoles
Summit Meadow	16 adults + 30 tadpoles (June 9) 72 transformed individuals (Sept 9)

not account for the timing of the decline (within the last approximately 20 years), nor its intensity (resulting in the complete elimination of some species), nor its broad scale (affecting all or nearly all species in the Yosemite area).

The most direct and unambiguous evidence about the effect of introduced fish (and possibly other effects) on amphibian populations will come from experiments on reintroducing amphibians into areas where they have disappeared. Reintroduced animals should be monitored closely to determine their fate. Elements measured in a monitoring program should include survival of animals released or their loss from the population, general condition of released animals, and reproductive effort and success of populations that persist. Initial reintroduction attempts could compare lakes that currently have fish with those that do not have fish. These initial efforts should be followed up with elimination of fish from selected ponds, lakes, and streams, followed by reintroduction of frogs. Reintroduction studies are discussed further by Fellers (1993).

Environmental effects (both natural phenomena such as drought, and human-caused changes) can best be evaluated by intensive monitoring of frog populations and their environment at selected sites, coupled with controlled laboratory studies, where appropriate. Field monitoring should include measurements of a broad range of water quality parameters, with an emphasis on pH and chemical pollutants, both of which have been implicated in amphibian mortality. Rainfall and water level / streamflow should also be recorded. As noted above, the lack of information on some forms of chemical pollutants may be the most significant deficiency in our knowledge of possible causes of the declines. All such environmental measurements should be recorded at a number of sites, to assess the range of variation. Detailed amphibian population information should be recorded at each site (see below).

4. Elimination of Non-native Predators

Widespread introduction of predatory fish has clearly had an adverse effect on native frog populations. In their original survey, Grinnell and Storer (1924, p. 664) noted that "frogs...do not occur in lakes which are stocked with trout," an observation that has been confirmed repeatedly since that time (Cory 1963, Moyle 1973, Hayes and Jennings 1986, Fellers and Drost 1993). In our own surveys in the Yosemite area, we only recorded larval frogs and toads occurring in water bodies with fish a very few times; and in these cases, the tadpoles were confined to densely vegetated shallows which were relatively inaccessible to fish.

If the native amphibians in the Yosemite area are going to recover some of their former numbers and distribution, there will have to be control of introduced fish in some areas, to make these habitat areas available to amphibians again. In larger lakes and drainages elimination of fish would be difficult or impossible, and in readily accessible areas it would be very unpopular with the fishing public. However fish could be removed from many smaller lakes, ponds, and stream systems in more remote areas. This would allow amphibians to return (or be reintroduced) to these areas while still allowing a popular use of the Park in other areas. One prospective area for a pilot fish removal program is Evelyn Lake and the surrounding small ponds. These ponds and lakes are discrete and isolated, so removal could be accomplished in a stepwise manner, and fish would be unable to reinvade ponds once they had been cleared. In addition, there is a small population of Yosemite Toads and possibly Mountain Yellow-legged Frogs (we found a single individual) remaining in this area that would be able to begin using the habitat immediately. Data collected on similar remnant frog and toad populations (Fellers, in progress) should be used to select additional areas for fish removal.

Potential methods for fish removal include seining and gill nets. R. Knapp (pers. comm.) has had good success with gill nets in eliminating large fish in small eastern Sierra Nevada lakes. In confined basins where its effects can be carefully controlled, rotenone may be considered for use. Since rotenone will also kill larval amphibians, however, its use should be restricted to late summer, after tadpoles have transformed.

Bullfrogs are voracious predators that take a wide variety of invertebrate and small vertebrate prey, including other frogs (Bury and Whelan 1984). In some areas they appear to have been a very important factor in the elimination of native frogs, as well as native garter snakes (Schwalbe and Rosen 1988). Although it is not clear what role Bullfrogs have had in the decline of frogs in the Sierra Nevada region (cf. Bury and Luckenbach 1976, Moyle 1973, and Hayes and Jennings 1986), they remain a potential threat to native amphibians and other aquatic and semiaquatic native species (see discussion in Schwalbe and Rosen 1988). Both by their predation on tadpoles and adult frogs, they are a threat to the success of any possible reintroduction programs. For this reason, we recommend that a removal program be initiated for bullfrogs as well.

Bullfrogs in Yosemite National Park are at present largely or entirely restricted to Yosemite Valley. However, they are capable of surviving in much higher areas (up to at least 1900 m; see Moyle 1973), so it is important that control measures be undertaken while the bullfrogs are still relatively restricted. We noted bullfrogs in the pond at the Ahwahnee Hotel, in a large pond along the north side of the Merced River just east of Indian Canyon Creek, and in overflow pools along the main stem of the Merced. They may be present in additional areas as well. These areas can be located relatively easily by searching the shallows and shoreline of ponds and slow-moving streams for the adult frogs during the spring and summer, and by listening for the distinctive deep call of the adults on late spring and summer evenings.

Once located, these frogs should be relatively easy to eliminate through a combination of seining for tadpoles and gigging adult frogs. Known or potential breeding sites should be swept with suitable-sized seine nets at repeated intervals through the spring and summer. This may be most effective in late summer when water levels are relatively low. Bullfrog tadpoles will be relatively easy to distinguish from other toads and frogs that may be present by their large size (up to 15 cm), olive coloration with dull yellow or white underparts, and relatively widely spaced eyes. Toad tadpoles are small (up to 5 cm, but usually smaller) and solid black, and Pacific Treefrog tadpoles are small (to 4.5 cm) and olive-brown, with eyes set on the margins of the head.

Adult frogs will be taken most effectively by searching at night with hand-held spotlights or headlamps. When shined in this manner, the frogs can be approached much more closely than they can in the daytime. They can then be taken with a long-handled gig or, if it is deemed safe, a pellet gun. Areas with adult frogs should be searched repeatedly through the spring and summer also. As with all control and removal programs, it is critical that intensive work be continued long enough to assure that the area is cleared of all individuals of the target species. This will probably require at least three years for Bullfrogs in Yosemite Valley. Bullfrogs are quite prolific, and will return quickly if all individuals are not removed.

5. Restoration of Extirpated Populations

Reintroduction experiments to study the effects of non-native fish will be an initial step toward restoring the critically low populations of some of the frog species in the Park. Larger scale restoration, covering many more lakes, meadows, and streams, will be needed to bring species such as Yosemite Toad, Foothill Yellow-legged Frog, and Mountain Yellow-legged Frog back to healthy population levels. We recommend that such large scale efforts wait until the cause of the declines can be further assessed. The latter stages of the three-year status assessment of amphibians in California (Fellers 1993) should be an appropriate time to consider the expansion of restoration efforts. Fellers' work will include genetic analyses of existing populations that will be important in selecting appropriate source populations for reintroductions.

6. Review State and Federal Protected Status

There have been efforts to gain Federal Endangered Species status for some or all populations of three of the species discussed here: 1) the Yosemite Toad; 2) the California Red-legged Frog; and 3) the Mountain Yellow-legged Frog. Our results argue strongly for such listing for all three of these species. Our surveys, and those of other researchers in the Sierra Nevada (D. Graber, Sequoia and Kings Canyon National Park; L. Cory, St. Mary's College), make clear that Foothill Yellow-legged Frog has also declined seriously in the Sierran portion of its range, perhaps to the point of extinction in the southern and central Sierra Nevada and we recommend similar protected status for this species. Given the extent of the declines that have already occurred, however, intensive research and management action on the amphibian fauna should not wait on official protected status.

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Appendix 1. Location and habitat information for the sites included in the 1992 survey of the Grinnell and Storer Yosemite section. Most sites are areas sampled and reported on by Grinnell and Storer, either in "Animal Life of the Yosemite" or in their original field notes. Several other sites were visited based on historical amphibian data other than the Grinnell and Storer survey.

Aspen Valley (Tuolumne Co., UTMN 41901, UTME 2561, Elev. 1875 m) - West side of Yosemite National Park, between South Fork Tuolumne River and Ackerson Creek. Meadow surrounded by cabins.

Babcock Lake (Mariposa Co., UTMN 41825, UTME 2891, Elev. 2739 m) - shallow pools and marshy ponds at NE end of lake, plus N and W sides of lake.

Blacks Creek (Mariposa Co., UTMN 41771, UTME 7459, Elev. 488 m) - Blacks Creek at Highway 132 - 1.5 km W of Coulterville.

Bohler Canyon (Mono Co., UTMN 41969, UTME 3132, Elev. 2165 m) - Bohler Canyon, just above confluence with Walker Creek. Approximately 2.6 km W of U.S. Highway 395.

Cascade Creek / North (Mariposa Co., UTMN 41789, UTME 2609, Elev. 1326 m) - Cascade Creek at Big Oak Flat Road, entrance to Yosemite Valley.

Cascade Creek / South (Mariposa Co., UTMN 41784, UTME 2610, Elev. 1049 m) - Cascade Creek at El Portal Road (Highway 140), entrance to Yosemite Valley.

Chinquapin (Mariposa Co., UTMN 41705, UTME 2618, Elev. 1841 m) - Checked creeks adjacent to road.

Crane Flat (Mariposa Co., UTMN 41820, UTME 2498, Elev. 1890 m) - Crane Flat meadows at junction of Tioga Road and Big Oak Flat Road. Meadows on both sides of the road.

Cuneo Creek (Mariposa Co., UTMN 41784, UTME 7482, Elev. 549 m) - Cuneo Creek and small pond behind dam, by ranch house along Priest-Coulterville Road 0.9 km N of County Road J20, 4 km N of Coulterville.

Dingley Creek (Tuolumne Co., UTMN 41986, UTME 2932, Elev. 3018 m) - Dingley Creek E of Young Lakes trail. 2990 m - 3050 m.

Dog Lake (Tuolumne Co., UTMN 41958, UTME 2942, Elev. 2793 m) - Dog Lake and three adjacent ponds (shown on USGS maps).

Appendix 1 (continued)

El Portal (Mariposa Co., UTMN 41746, UTME 2499, Elev. 610 m) - Crane Creek at Highway 140, within town limits of El Portal. Creek section N of road.

Elizabeth Lake (Tuolumne Co., UTMN 41912, UTME 2915, Elev. 2899 m) - Entire shoreline of lake, including marshy ponds at W end of lake and 400 m of outflow stream and upper Unicorn Creek.

Evelyn Lake (Tuolumne Co., UTMN 41869, UTME 2954, Elev. 3149 m) - East and north shores of Evelyn Lake, including bordering marshes, ponds, and feeder streams, and upper part of outlet stream. Account in Grinnell and Storer notes.

Evelyn Lake 2 (Tuolumne Co., UTMN 41871, UTME 2967, Elev. 3186 m) - Unnamed lake 1.3 km E of Evelyn Lake. Mapped lake, not mentioned by Grinnell and Storer.

Farrington Ranch (Mono Co., UTMN 41974, UTME 3157, Elev. 2073 m) - Walker Creek on W side of U.S. Highway 395. Area survey extended from highway up creek approximately 1.5 km.

Feliciana Mountain (Mariposa Co., UTMN 41636, UTME 2456, Elev. 1079 m) - Sweetwater Creek, 3 km SE of Feliciana Mtn. Take Triangle Road off Highway 140 10.4 km to Jerseydale Rd, then Jerseydale Road. to Sweetwater Mine, then on foot down trail to Sweetwater Creek.

Fletcher Creek (Mariposa Co., UTMN 41839, UTME 2912, Elev. 2805 m) - Fletcher Creek, beginning where trail intercepts creek about 1.5 km downstream from Upper Fletcher Lake, downstream to large meadow S of Emeric Lake. 2700 m - 2960 m.

Fletcher Lake (Mariposa Co., UTMN 41856, UTME 2939, Elev. 3110 m) - Lower (west) end, outlet stream, and seeps and streams along SW side of Upper Fletcher Lake. Also separate pool near SW edge of lake.

G-7 Meadow (Mariposa Co., UTMN 41760, UTME 2719, Elev. 2348 m) - W side of Glacier Point Road, 13 km W of Badger Pass Road - at the G-7 roadside marker. South of Sentinel Dome.

Gem Lake (Mono Co., UTMN 41812, UTME 3099, Elev. 2759 m) - Gem Lake, SW Mono County, Inyo National Forest.

Half Moon Meadow (Mariposa Co., UTMN 41969, UTME 2762, Elev. 2698 m) - Meadow and stream including various associated ponds.

Appendix 1 (continued)

Hazel Green (Mariposa Co., UTMN 41837, UTME 2476, Elev. 1683 m) - Hazel Green Ranch - 6.5 km WNW of Crane Flat (junction of Tioga Rd. and Big Oak Flat Road), 0.5 km W of Big Oak Flat Rd. Open area in forest.

Head of Lyell Canyon (Tuolumne Co., UTMN 41811, UTME 3011, Elev. 3201 m) - Both forks of stream fed by meltwater from Lyell Glacier, including several pothole lakes and marshes along the course of the stream.

Indian Canyon Creek (Mariposa Co., UTMN 41844, UTME 2743, Elev. 2421 m) - Indian Canyon Creek above N side of Yosemite Valley, from about 2070 - 2160 m elevation. (Following Grinnell and Storer, the area surveyed includes Lehamite Creek from its confluence with Indian Canyon Creek up to just south of the Tioga Road, from about 2200 - 2390 m elevation).

Ireland Lake (Tuolumne Co., UTMN 41849, UTME 2978, Elev. 3273 m) - East and north shores of Ireland Lake, and two small ponds N of lake and W of outlet stream.

La Grange (Stanislaus Co., UTMN 41716, UTME 7239, Elev. 122 m) - La Grange - Old La Grange Bridge over Tuolumne River. Searched edge of river.

La Grange / West (Stanislaus Co., UTMN 41692, UTME 7212, Elev. 91 m) - Bosso Bridge, Tuolumne River at Highway 132. Pond and adjacent river.

Leidig Meadow (Mariposa Co., UTMN 41799, UTME 2708, Elev. 1220 m) - N side of Merced River SW of Sunnyside Camp. "Yosemite Valley west".

Lyell Fork / Upper (Tuolumne Co., UTMN 41876, UTME 3001, Elev. 2713 m) - Series of small ponds along W side of Lyell Fork S of Ireland Creek.

Lyell Fork Tuolumne River (Tuolumne Co., UTMN 41920, UTME 2980, Elev. 2683 m) - Sites along W shore of Lyell Fork, from John Muir trail to beyond junction with Ireland Creek. Includes bordering ponds, marshes, and tributaries Tuolumne Meadows to head, 2650 - 2750 m.

Maclure Creek (Tuolumne Co., UTMN 41820, UTME 2996, Elev. 3201 m) - Maclure Creek and 3 lakes along its course, above 10400 ft. contour. Elev. 11450 ft at Maclure Lake.

McCarthy Ranch (Mariposa Co., UTMN 41812, UTME 7529, Elev. 1113 m) - Bean Creek at Highway J20 bridge, in Greeley Hill - 6.8 km NE of Coulterville. "3 mi NE of Coulterville".

Appendix 1 (continued)

McGee Lake / Glen Aulin (Tuolumne Co., UTMN 41980, UTME 2870, Elev. 2470 m) - Lake and stream between Glen Aulin and the lake.

Medlicott Dome (Mariposa Co., UTMN 41923, UTME 2867, Elev. 2896 m) - 2 lakes on E and N shoulders of Medlicott Dome. Northerly lake is W of Mariuolumne Dome.

Merced Grove (Mariposa Co., UTMN 41816, UTME 2409, Elev. 1646 m) - Moss Creek - Merced Grove of Giant Sequoias, 3.5 km WSW of Crane Flat. Only a modest amount of good habitat.

Merced Lake (Mariposa Co., UTMN 41795, UTME 2856, Elev. 2012 m) - Merced Lake, primarily marshes at E end and NE corner of lake, and N shore. Following descriptions in Grinnell and Storer, we also searched areas along the Merced River, from Washburn Lake to Sunrise Creek, 7200-6100 ft.

Mono / Dry Creek (Mono Co., UTMN 41924, UTME 3325, Elev. 2402 m) - Grinnell camp was at Mono Mills (now deserted) along Highway 120. Our survey site was along Dry Creek where Hwy 120 crosses, 5.6 km SE of Mono Mills.

Mono Lake (Mono Co., UTMN 42068, UTME 3120, Elev. 1970 m) - West shore of Mono Lake at Mono Lake Post Office, along U.S. Highway 395. Creek draining into lake and broad, marshy flats along shore of lake.

Mono Meadow (Mariposa Co., UTMN 41725, UTME 2727, Elev. 2134 m) - Meadow SW of trail.

Mt. Conness / White Mtn. (Tuolumne Co., UTMN 42020, UTME 2960, Elev. 3171 m) - Area includes small lake (series of ponds) S of Mt. Conness and NW of White Mtn. 3170 & 3230 m.

Mt. Hoffmann (Mariposa Co., UTMN 41926, UTME 2792, Elev. 3049 m) - Series of 7 lakes on the N and NW flanks of Mount Hoffmann, and on the W side of the ridge W of May Lake.

Peregoy Meadow (Mariposa Co., UTMN 41721, UTME 2687, Elev. 2195 m) - Peregoy Meadow, primarily S side of Glacier Point Road, E of Badger Pass. Account in Grinnell & Storer notes.

Piney Creek (Mariposa Co., UTMN 41747, UTME 7365, Elev. 259 m) - Piney Creek at end of Piney Creek Road off Highway 132 - 11 km WSW of Coulterville.

Appendix 1 (continued)

Pleasant Valley (Mariposa Co., UTMN 41703, UTME 7391, Elev. 183 m) - Former site of Pleasant Valley, along Merced River at junction with Piney Creek. Now under water of Lake McClure / Exchequer Reservoir - not surveyed.

Porcupine Flat (Mariposa Co., UTMN 41882, UTME 2739, Elev. 2470 m) - Porcupine Creek and adjacent marshes and tributaries, from Tioga Road N (upstream) for approximately 2 km.

Rush Creek (Mono Co., UTMN 41848, UTME 3132, Elev. 2198 m) - West shore of Rush Creek, along Highway 158 2.7 km S of Grant Lake and 1 km N of Silver Lake.

Simmons Peak (Tuolumne Co., UTMN 41826, UTME 2978, Elev. 3445 m) - Series of 6 lakes on high bench E and NE of Simmons Peak, and along outflow of cirque N of Simmons Peak and S of peak with elevation 11640 ft. on USGS maps; 3450 - 3480 m.

Smith Creek (Mariposa Co., UTMN 41822, UTME 7551, Elev. 899 m) - Smith Creek along Greeley Hill Rd. at junction with Smith Station Rd. (Highway J20) - 7 km S of Highway 120 and 9.5 km NE of Coulterville. Location also called "Dudley".

Snelling (Merced Co., UTMN 41555, UTME 7265, Elev. 61 m) - Snelling - Merced River at Snelling Road. Also County Road J16 0.16 km W of Snelling.

Snow Flat / Snow Creek (Mariposa Co., UTMN 41888, UTME 2796, Elev. 2652 m) - Snow Creek along spur road to May Lake trailhead; pond on S side of Tioga Road, E of Snow Creek; tributary of Snow Creek 0.6 km W of May Lake Rd.

Summit Meadow (Mariposa Co., UTMN 41728, UTME 2660, Elev. 2271 m) - South side of Glacier Point Road, 1.6 km E of Badger Pass Road.

Sunrise Creek (Mariposa Co., UTMN 41790, UTME 2787, Elev. 2854 m) - Lower Sunrise Creek, from confluence with Merced River upstream 150 m. Stream intermittent, dried up at this point.

Tamarack Flat (Mariposa Co., UTMN 41816, UTME 2599, Elev. 2043 m) - Tamarack Flat and Tamarack Creek at National Park Service campground.

Ten Lakes (Tuolumne Co., UTMN 41980, UTME 2782, Elev. 2854 m) - Series of lakes and associated ponds as well as connecting streams. Six sites.

Tenaya Lake (Mariposa Co., UTMN 41896, UTME 2835, Elev. 2484 m) - Lake border as well as ponds and stream to the west.

Appendix 1 (continued)

Tioga Pass (Mono Co., UTMN 41989, UTME 3020, Elev. 3049 m) - Meadows on E side of Highway 120, from S end of Tioga Lake up to Tioga Pass and over into uppermost portion of Dana Meadows. Account in Grinnell and Storer notes.

Tuolumne Meadows East (Tuolumne Co., UTMN 41945, UTME 2928, Elev. 2619 m) - Meadows S and W of Lembert Dome.

Tuolumne Meadows West (Tuolumne Co., UTMN 41950, UTME 2900, Elev. 2608 m) - West end of Tuolumne Meadows, from Tuolumne River to Pothole Dome.

Vogelsang Lake (Mariposa Co., UTMN 41845, UTME 2936, Elev. 3152 m) - Shoreline, outlet stream, and marsh at W end of Vogelsang Lake.

Walker Lake (Mono Co., UTMN 41935, UTME 3092, Elev. 2421 m) - West end of Walker Lake - lakeshore, marshes at end of lake, and inflow stream.

Warren Fork (Mono Co., UTMN 42034, UTME 3037, Elev. 2774 m) - Warren Fork of Lee Vining Creek, NE of Tioga Peak and NE of Tioga Pass; Inyo National Forest.

Westfall Meadow (Mariposa Co., UTMN 41704, UTME 2678, Elev. 2165 m) - Westfall Meadow, S of Peregoy Meadow and Glacier Point Road. Account in Grinnell & Storer notes.

Yosemite Valley (Mariposa Co., UTMN 41806, UTME 2730, Elev. 1223 m) - Yosemite Valley, Ahwahnee Meadow - N of Curry Village, W of Ahwahnee Hotel. Yosemite Valley east.

Young Lakes (Tuolumne Co., UTMN 42013, UTME 2945, Elev. 3003 m) - Lower, middle, and upper Young Lakes, including wet meadows around lower and middle lakes. Includes 'Ragged Peak' of Grinnell & Storer.

Appendix 2. Occurrence and numbers of amphibians at field sites sampled along the Yosemite transect in 1992. Survey sites are described in Appendix 1. Time begin and Time end indicate the time span the area was actively searched. Observer initials are the authors (CAD and GMF) and National Park Service volunteer Rebecca Hamman (RH). "Adults" includes all transformed frogs and toads; "Larvae" refers to tadpoles and transforming frogs still confined to the water. "NC" under adults or larvae stands for "not counted;" "99" indicates a large number of individuals, not counted.

Survey Site	Date	Begin	End	Observer	Species	Adults	Larvae	Notes
Aspen Valley	06/08/92	1730	1900	CAD/GMF	*P. regilla*	2	0	Large meadow in pine forest
Babcock Lake	07/08/92	1330	1500	CAD/RH	*P. regilla*	0	250	600m of lakeshore 200m of sm ponds
Blacks Creek	05/12/92	1505	1620	CAD/GMF	*P. regilla*	0	99	Juvenile *Clemmys marmorata* and *Eumeces gilberti* also seen
Bohler Canyon	06/10/92	1125	1200	CAD/GMF		0	0	Little good habitat
Cascade Creek /North	05/14/92	1205	1220	CAD/GMF		0	0	Cascade Creek at Big Oak Flat Road
Cascade Creek /South	05/14/92	750	850	CAD/GMF		0	0	Cascade Creek at Highway 140. *Sceloporus* sp. seen
Chinquapin	06/09/92	1435	1505	CAD/GMF		0	0	
Crane Flat	05/13/92	1330	1400	CAD/GMF		0	0	Meadow beyond campground. No amphibians seen
Crane Flat	05/13/92	1415	1510	CAD/GMF		0	0	Meadow on W side of road
Crane Flat	06/09/92	1910	1920	CAD/GMF	*P. regilla*	0	0	Report of chorus in May
Cuneo Creek	06/08/92	1430	1515	CAD/GMF	*P. regilla*	NC	0	"Hyla" reported as present by local resident
Cuneo Creek	06/08/92	1430	1515	CAD/GMF	*R. catesbeiana*	6	0	0.5 mi N of County Rd. J20 and Greeley Hill Road
Cuneo Creek	06/08/92	1430	1515	CAD/GMF	*Rana aurora*	0	99	Large number of tadpoles in sm pond behind concrete dam
Cuneo Creek	07/15/92	1400	1420	GMF		0	0	Site where *Rana aurora* found earlier
Dingley Creek	07/07/92	1200	1330	GMF	*Bufo canorus*	1	50	Dingley Creek E of Young Lakes trail
Dog Lake	07/13/92	1245	1445	GMF	*P. regilla*	0	5375	Dog Lake and adjacent ponds - see notes
El Portal	05/14/92	1245	1315	CAD/GMF	*P. regilla*	NC	0	Small chorus heard last night
Elizabeth Lake	07/13/92	950	1050	GMF	*Bufo canorus*	0	2050	2 areas - see field notes
Elizabeth Lake	07/13/92	950	1050	GMF	*P. regilla*	0	1	Partial length and width - see field notes
Elizabeth Lake	09/10/92	1025	1125	CAD	*P. regilla*	2	0	1300m of lakeshore, 400 m of stream
Evelyn Lake 2	07/07/92	1030	1145	CAD/RH	*Bufo canorus*	1	60	Lake 1.3 km E of Evelyn Lake

Appendix 2 (continued)

Survey Site	Date	Begin	End	Observer	Species	Adults	Larvae	Notes
Evelyn Lake 2	07/07/92	1030	1145	CAD/RH	*P. regilla*	0	10	Lake 1.3 km E of Evelyn Lake
Evelyn Lake	07/07/92	1300	1410	CAD/RH	*Bufo canorus*	0	3	In deep, silty inflow streams
Evelyn Lake	07/07/92	1300	1410	CAD/RH	*P. regilla*	0	15	In small overflow ponds on N side of lake
Evelyn Lake	07/07/92	1300	1410	CAD/RH	*Rana muscosa*	1	0	Overflow pond by outlet stream
Evelyn Lake	07/07/92	1420	1450	CAD/RH	*P. regilla*	0	900	Small pond NNW of W end of Evelyn Lake
Evelyn Lake	08/05/92	915	1000	CAD	*Bufo canorus*	0	6	Transformlings along E side of lake
Evelyn Lake	08/05/92	915	1000	CAD	*P. regilla*	0	26	In marginal ponds around lake
Evelyn Lake	08/05/92	915	1000	CAD	*Rana muscosa*	1	0	Along outflow stream from lake
Farrington Ranch	06/10/92	1810	1910	CAD/GMF		0	0	Fast flowing stream
Feliciana Mountain	05/14/92	1530	1630	CAD/GMF	Batrachoseps sp.	2	0	Under logs along creek. 1 collected
Fletcher Creek	07/08/92	1020	1205	CAD	*P. regilla*	0	3	*Pseudacris* in potholes - see notes
Fletcher Lake	07/07/92	1545	1605	CAD/RH		0	0	Fairy shrimp in small pool at SW end of lake
Fletcher Lake	07/08/92	830	930	CAD/RH	*P. regilla*	1	0	Seep and pools at NW base of Fletcher Peak
G-7 Meadow	09/09/92	1145	1245	CAD	*P. regilla*	30	25	Most adults along banks of small pools
G-7 Meadow	09/09/92	1145	1245	CAD	*Rana muscosa*	1	0	Lone male. Meadow mostly dry
Half Moon Meadow	07/09/92	1245	1330	GMF	*P. regilla*	0	50	Small ponds along stream
Hazel Green	05/13/92	845	945	CAD/GMF	*P. regilla*	0	200	One *Sceloporus* sp. seen
Head of Lyell Canyon	08/04/92	845	930	CAD	*Bufo canorus*	1	150	Meltwater pond - see notes
Head of Lyell Canyon	08/04/92	930	1130	CAD		0	0	Headwaters of Lyell Fork - east branch
Head of Lyell Canyon	08/04/92	1230	1330	CAD		0	0	Headwaters of Lyell Fork - west branch
Indian Canyon Creek	09/09/92	1700	1900	CAD	*P. regilla*	2	0	Newly transformed
Indian Canyon Creek	09/09/92	1930	2015	CAD		0	0	From trail junction S toward Valley
Ireland Lake	08/05/92	705	750	CAD		0	0	Lake and adjacent potholes
La Grange / West	05/11/92	1310	1500	CAD/GMF	*R. catesbeiana*	99	99	
La Grange	05/11/92	1625	1710	CAD/GMF	*R. catesbeiana*	NC	9	Unidentified crayfish in river
Leidig Meadow	05/14/92	1045	1145	CAD/GMF	*Bufo boreas*	1	30	Large female adult. Egg strings in pools
Leidig Meadow	05/14/92	1045	1145	CAD/GMF	*R. catesbeiana*	1	5	*Rana* larvae collected

Appendix 2 (continued)

Survey Site	Date	Begin	End	Observer	Species	Adults	Larvae	Notes
Lyell Fork / Upper	08/03/92	1800	1850	CAD		0	0	Two ponds 0.8 & 2.5 acres
Lyell Fork Tuolumne R.	07/06/92	1300	1315	CAD	*P. regilla*	0	99	N of Lyell Fork, along John Muir trail
Lyell Fork Tuolumne R.	07/06/92	1615	1700	CAD		0	0	Ponds along W side of Lyell Fork
Lyell Fork Tuolumne R.	07/06/92	1800	1830	CAD/RH		0	0	Lyell Fork N of Ireland Creek
Lyell Fork Tuolumne R.	08/03/92	1300	1930	CAD		0	0	Streams and meltwater pools
Lyell Fork Tuolumne R.	08/03/92	1345	1400	CAD	*P. regilla*	5	150	Pools at bend in Lyell Fork
Maclure Creek	08/04/92	1500	1545	CAD		0	0	Large lake at head of Maclure Creek
Maclure Creek	08/04/92	1700	1740	CAD		0	0	Middle stretch of Maclure Creek
McCarthy Ranch	05/12/92	1250	1330	CAD/GMF	*P. regilla*	0	4	
McCarthy Ranch	05/12/92	1250	1330	CAD/GMF	*R. catesbeiana*	25	25	
McCarthy Ranch	06/08/92	1545	1555	CAD/GMF	*R. catesbeiana*	6	0	Four large *Clemmys* S of bridge
McGee Lake /Glen Aulin	07/14/92	1000	1030	GMF		0	0	Trout in river and stream
McGee Lake /Glen Aulin	07/14/92	1100	1145	GMF	*P. regilla*	0	301	Lake and adjacent marsh - see notes
Medlicott Dome	09/10/92	1420	1540	CAD	*P. regilla*	10	23	Eight dead adults, 1 dead tadpole - see notes
Merced Grove	05/13/92	1100	1200	CAD/GMF		0	0	No amphibians
Merced Lake	07/08/92	1730	1845	CAD/RH	*P. regilla*	0	94	*Pseudacris* in marshes. Probable *Thamnophis couchi* along shore of lake
Mono / Dry Creek	06/10/92	1710	1800	CAD/GMF		0	0	Mostly dry. Few marshy pools
Mono Lake	06/10/92	905	1030	CAD/GMF		0	0	Marshy areas N of Mono Lake Post Office
Mono Meadow	06/09/92	1130	1230	CAD/GMF	*P. regilla*	0	200	Trout in larger potholes
Mono Meadow	06/09/92	1130	1230	CAD/GMF	*Rana muscosa*	0	1	Single tadpole - net capture
Mt Conness /White Mtn	07/06/92	1250	1320	GMF		0	0	Small lake S of Mt. Conness and NW of White Mtn
Mt Conness /White Mtn	07/06/92	1300	1345	GMF	*Bufo canorus*	0	225	Meadow at small lake NW of White Mtn
Mt Hoffmann	08/05/92	1650	2040	CAD	*P. regilla*	0	2700	*Pseudacris* in 3 of 7 lakes checked - see notes
Mt Hoffmann	08/05/92	1650	2040	CAD	*Rana muscosa*	0	113	Lakes H6 and H7 - see notes and map
Peregoy Meadow	06/09/92	940	1040	GMF	*P. regilla*	0	15	Trout at S end of meadow, frogs at N
Piney Creek	05/12/92	1705	1820	CAD/GMF	*P. regilla*	0	40	

Appendix 2 (continued)

Survey Site	Date	Begin	End	Observer	Species	Adults	Larvae	Notes
Porcupine Flat	06/09/92	2020	2035	CAD/GMF		0	0	Listened for calls
Porcupine Flat	06/11/92	1500	1700	CAD/GMF	*Bufo canorus*	7	450	Seven small toads -- see notes
Porcupine Flat	06/11/92	1500	1700	CAD/GMF	*P. regilla*	1	0	Fish in creek
Porcupine Flat	07/15/92	1145	1215	GMF		0	0	Site where *Bufo canorus* found earlier
Porcupine Flat	09/10/92	1720	1900	CAD	*Bufo canorus*	2	0	Wet meadows along W side of creek
Porcupine Flat	09/10/92	1720	1900	CAD	*P. regilla*	NC	0	Wet meadows along W side of creek
Rush Creek	06/10/92	1535	1625	CAD/GMF		0	0	Fast-flowing creek with fish
Simmons Peak	08/04/92	1600	1900	CAD		0	0	Checked 1600-1630 pm and 1815-1900 pm. See notes
Smith Creek	05/12/92	1145	1230	CAD/GMF	*P. regilla*	0	30	
Snelling	05/11/92	1745	1845	CAD/GMF	*R. catesbeiana*	NC	99	Unidentified crayfish in river
Snelling	05/11/92	1915	1930	CAD/GMF	*P. regilla*	3	0	
Snow Flat /Snow Creek	07/15/92	1100	1120	GMF	*P. regilla*	0	1	Two *Thamnophis elegans*, 24" and 20"
Snow Flat /Snow Creek	08/06/92	900	1130	CAD		0	0	Snow Creek and Snow Flat -see notes
Summit Meadow	06/09/92	1320	1405	CAD/GMF	*P. regilla*	2	200	
Summit Meadow	06/09/92	1320	1405	CAD/GMF	*Rana muscosa*	16	30	Four large adults, 12 small (ca. 30 mm)
Summit Meadow	07/02/92	1030	1100	GMF	*Rana muscosa*	18	8	
Summit Meadow	09/09/92	915	1030	CAD	*P. regilla*	8	0	Hyla active in surrounding meadow
Summit Meadow	09/09/92	915	1030	CAD	*Rana muscosa*	72	1	Many transformed individuals
Sunrise Creek	07/09/92	1115	1145	CAD/RH		0	0	Lower Sunrise Creek to Merced River
Tamarack Flat	06/12/92	850	950	CAD/GMF		0	0	Fish in stream. No marshes or ponds
Ten Lakes	07/10/92	930	1600	GMF	*P. regilla*	1	660	Several lakes and ponds - see notes
Tioga Pass	06/09/92	2140	2150	CAD/GMF	*P. regilla*	10	0	Chorus of 10-20
Tioga Pass	06/11/92	850	1030	CAD/GMF	*Bufo canorus*	0	350	Pothole 30-40m W of Tioga Lake
Tioga Pass	06/11/92	850	1030	CAD/GMF	*P. regilla*	0	200	Few frogs for available habitat
Tioga Pass	07/15/92	915	950	GMF	*Bufo canorus*	0	75	Two pond sites - see notes
Tuolumne Mead. East	06/09/92	2120	2130	CAD/GMF		0	0	Listened for calls
Tuolumne Mead. East	06/11/92	1110	1205	CAD/GMF		0	0	Near Lembert Dome. Meadows dry

Appendix 2 (continued)

Survey Site	Date	Begin	End	Observer	Species	Adults	Larvae	Notes
Tuolumne Mead. West	06/09/92	2110	2115	CAD/GMF	*P. regilla*	8	0	Listened for calls
Tuolumne Mead. West	06/11/92	1245	1405	CAD/GMF	*P. regilla*	0	50	Much good habitat, few frogs
Tuolumne Mead. West	07/03/92	1300	1330	GMF	*P. regilla*	1	50	Pothole Dome pond. 4 *Thamnophis elegans*
Tuolumne Mead. West	07/03/92	1400	1430	GMF	*P. regilla*	0	250	Pond 400 m NW of Pothole Dome
Tuolumne Mead. West	07/03/92	1500	1525	GMF	*P. regilla*	0	200	Pothole pond NE of Tuolumne River
Vogelsang Lake	07/07/92	1730	1830	CAD/RH	*P. regilla*	2	200	
Walker Lake	06/10/92	1330	1430	CAD/GMF		0	0	
Westfall Meadow	06/12/92	1220	1420	GMF	*Bufo canorus*	1	10000	Very good, extensive habitat
Westfall Meadow	06/12/92	1220	1420	GMF	*P. regilla*	1	2000	Very good, extensive habitat
Yosemite Valley	05/13/92	1600	1635	CAD/GMF	*P. regilla*	0	30	N of Curry Village. 2 egg masses
Yosemite Valley	05/13/92	1645	1715	CAD/GMF	*Bufo boreas*	2	20	W of Ahwahnee. 1 dead *Bufo boreas* adult
Yosemite Valley	05/13/92	1710	1740	CAD/GMF		0	0	Indian Canyon Creek to Merced River
Yosemite Valley	05/13/92	1740	1800	CAD/GMF	*P. regilla*	0	20	E of Indian Canyon Creek and Merced River
Yosemite Valley	05/13/92	1740	1800	CAD/GMF	*R. catesbeiana*	4	20	E of Indian Canyon Creek and Merced River
Young Lakes	07/05/92	1600	1640	GMF	*Bufo canorus*	3	800	NW corner and W end of lower Young Lake
Young Lakes	07/06/92	945	1000	GMF		0	0	E side of lower Young Lake
Young Lakes	07/06/92	1000	1100	GMF	*Bufo canorus*	0	400	Damp meadow, middle Young Lake
Young Lakes	07/06/92	1000	1100	GMF	*P. regilla*	0	2	Damp meadow, middle Young Lake
Young Lakes	07/06/92	1100	1130	GMF		0	0	Upper Young Lake. Little habitat
Young Lakes	07/07/92	900	945	GMF		0	0	Meadow 500m NW lower Young Lake
Other sites	05/11/92	1545	1610	CAD/GMF	*R. catesbeiana*	99	NC	La Grange cemetery 0.4 mi W of road J59
Other sites	06/09/92	1940	2000	CAD/GMF		0	0	Siesta Lake along Tioga Road - listened for calls
Other sites	06/29/92	1330	1430	GMF	*P. regilla*	0	50	Woodland pond 1 mile SW of Tenaya Lake
Other sites	07/07/92	900	920	CAD		0	0	Ireland Creek NNE of Ireland Lake
Other sites	07/09/92	830	835	CAD		0	0	Intermittent stream at Bunnell cascade along Merced River

Appendix 2 (continued)

Survey Site	Date	Begin	End	Observer	Species	Adults	Larvae	Notes
Other sites	07/09/92	1000	1010	CAD/RH		0	0	Overflow pool on N side of Merced River E of Sunrise Creek
Other sites	09/10/92	1245	1300	CAD	*P. regilla*	3	1	Small pond along Tioga Road 2.6 mi N of Tenaya Lake
Other sites	09/11/92	1150	1220	CAD		0	0	Mirror lake - isolated ponds and adjacent Tenaya Creek

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