Declining Amphibian Populations Task Force (DAPTF)
California-Nevada Working Group
January 13-14, 2005
Berkeley, California

ABSTRACTS

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Update on the Mountain Yellow-legged Frog Restoration Project in Sequoia and Kings Canyon National Parks

To help reverse the decline of the mountain yellow-legged frog (Rana muscosa), Sequoia and Kings Canyon National Parks began removing introduced trout in 2001 from six lakes and adjacent streams using gill nets and backpack electrofishers. We also began restoring a seventh lake in 2004. In total we have removed more than 11,000 trout and eradicated three populations, and expect to eradicate two additional populations in 2005. We also conducted multiple shoreline surveys per season in the restoration lakes to assess frog recovery. By 2004 we measured large increases in mountain yellow-legged frog abundance in five of the restoration lakes; one lake showed an increase of 77 times in the average number of individuals detected per survey in 2004 versus 2001. Furthermore, in several of the restoration lakes we observed increased densities of aquatic invertebrates, birds and snakes, indicating that many components of the ecosystem may be responding favorably to trout eradication.

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Seasonal Movements of the Foothill Yellow-legged Frog in Tehama County, California

Complementary resources for amphibians (e.g., breeding, foraging, and refugia) change with time and are separated in space. Understanding the extent and frequency of seasonal movements between these resources is important for the development of successful conservation plans. Radio-telemetry was used to study the movements and habitat use of the foothill yellow-legged frog (*Rana boylii*) in Tehama, County, California. Sixty frogs (11 males and 49 females) occupying habitat along Red Bank Creek were opportunistically captured, fitted with radio-transmitters, and tracked to describe seasonal movements. Females were tracked during two study periods (spring and autumn), while males were only tracked in the spring. Movements were mapped and habitat use analyzed using global positioning and geographic information systems. Site-specific environmental conditions were monitored to determine if movements were correlated with weather conditions. Patterns of spatial use, determined from 879 tracking

observations, indicated that frogs rarely ventured far from the stream channel. Males and females displayed different movement patterns. The greatest cumulative seasonal distances traveled by a male and female frog were 0.65 km and 7.03 km, respectively; these distances were traveled during the spring season. Males had smaller home ranges than females, and there was no difference between female home ranges across seasons. These results and other preliminary findings useful for management of this species will be discussed.

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Update on Chytridiomycosis in *Rana muscosa*

I will give an update of our current work studying the effects of the disease, chytridiomycosis (caused by the chytrid fungus *Batrachochytrium dendrobatidis*), on mountain yellow-legged frogs. I will discuss the use of swabbing and real time PCR to detect and quantify the fungus on live frogs in the field and laboratory. I will discuss our recent observations on the spread of the disease through a watershed, and its impact on frog populations. Finally, I will talk about our ongoing efforts to compare the disease dynamics at sites at which we are observing frog die-offs due to chytridiomycosis, versus sites at which the frog populations appear to be persisting with the disease.

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The Sierra Nevada Amphibian Monitoring Program: A Long-Term Bioregional Approach

In 2002, the USDA Forest Service initiated a long-term, bioregional monitoring program for two aquatic frog species, the mountain yellow-legged frog (*Rana muscosa*) and Yosemite toad (*Bufo canorus*), in the Sierra Nevada, CA. Both species are USFWS candidate species and recent assessments indicate they have disappeared from a large proportion of their historic localities. The Sierra Nevada Amphibian Monitoring Program assesses the status and change of populations and habitat for these two species. The monitoring is designed to make inferences at the scale of the species' ranges in the Sierra Nevada and to provide information for the 10-year Forest Service planning cycle. The monitoring combines extensive and intensive components in one integrated design. Extensively, for each species, 130 small watersheds (2-4 km^2) will be surveyed throughout the range of each species over a 5-year cycle, with 20% revisited annually. Population trends are measured by breeding occupancy (number of occupied watersheds, number of occupied sites/watershed). Habitat trends are measured by attributes that assess hydrologic condition, habitat matrix, cover, water temperature, disturbance, and general characterization. Intensively, we will select three small watersheds for each species and collect more detailed abundance, life history, and habitat data. For both components, we survey all lentic and a sample of lotic sites within each watershed. The extensive component was initiated during 2002 and

approximately 70 watersheds were surveyed over the past three years, with 18 re-surveyed for at least two years. Results from this monitoring will help determine whether USDA Forest Service management practices are promoting desired conditions for these species' populations and habitat throughout their ranges in the Sierra Nevada, increase our knowledge of population dynamics and habitat requirements, and provide information for making more informed management decisions.

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Amphibian Conservation Strategies for 5 Sierra Nevada Frog Species

As part of the Sierra Nevada Forest Plan Amendment (SNFPA) Record of Decision (ROD), the U.S. Forest Service committed to completing conservation assessments for five aquatic frog species, the mountain yellow-legged frog (*Rana muscosa*), Yosemite toad (*Bufo canorus*), foothill yellow-legged frog (*Rana boylii*), Cascades frog (*Rana cascadae*), and northern leopard frog (*Rana pipiens*). These are in progress in cooperation with other federal agencies, state agencies, universities, and research scientists. The conservation assessments are intended to be the first phase in a three-phase process that includes the conservation assessments, conservation strategies, and conservation agreements. The assessments provide the information base and scientific foundation for the conservation strategies. The strategies would recommend specific conservation actions, which would lead to conservation agreements among various agencies and partners. Working groups comprised of interagency specialists and species experts were formed for each species. Work began in December, 2001, and is scheduled to be completed in 2005. Currently, the assessments are approximately 75% complete. The next drafts to be presented to the working teams are scheduled for completion in March, 2005. The final product, which will be peer reviewed by scientists and key management disciplines, is intended for publication.

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Amphibian Conservation Through Integrated Data Management: The ARMI (Amphibian Research and Monitoring Initiative) Model

Successful management of herpetofauna relies on integrated management of ecological and physiological research data. In southern California, the Western Ecological Research Center of the US Geological Survey (USGS) is working with researchers, city, county, state and Federal resource agencies to develop strategies to supply data that meets these management needs. Land managers and regulators rely on access to the most current and applicable research data available in making sound decisions to conserve amphibian diversity in perpetuity. Integrated data management allows researchers, agencies and consultants to share non sensitive information regarding their independent research, inventory and monitoring projects. Several data management strategies ranging from local and regional partners to Federal partners including Departments of Interior, Defense and Agriculture that are collaborating in the national USGS program Amphibian Research and Monitoring Initiative (ARMI) were examined to determine how to meet needs of the managers. Federal and university researchers and statisticians also contributed greatly to impart study design needs and capabilities and to insure data of highest value. Together, these concepts provided a base on which a strategy could be developed. To develop the data management strategy that is currently being tested by USGS, several goals needed to be accomplished. Stringent database development has provided a backbone structure that can meet the needs of the managers and still provide flexibility for the researchers. Networking solutions have been developed to allow secure access to managers and researchers whether centrally located or at remote locations. Multiple data entry and recall tools have been developed to meet the demands of different study designs, including full digital data collection utilizing hand held computers with standardized forms, queries and reports. Coupled with sound science, this strategy of integrated data management will be of great benefit to the researchers and an invaluable tool to land mangers.

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Life History of Post-metamorphic Tailed Frogs in North Coastal California

The tailed frog (*Ascaphus truei*) is potentially sensitive to habitat alterations often associated with timber harvest practices, such as increased sediment load in streams and increases in water temperatures. Understanding the ecology of tailed frogs is critical for effective management of this species. Most research on tailed frogs has focused on the larvae, because they are easier to sample and are presumed to be more susceptible to timber harvest impacts compared to adults. Therefore, little is known about the life history and ecology of post-metamorphic populations of tailed frogs. We conducted nocturnal surveys of post-metamorphic tailed frogs on six streams from 2002-04 using mark-recapture to determine sizes of age classes, site fidelity, seasonal activity, reproductive chronology, and growth rates. Tailed frogs in these streams exhibited little within channel movement (mean = 9.5 m). However, movements were highly variable ranging from 0-106 m. Frogs were active within the channel and riparian zone from March to November with peak activity from July-September for adults and from May-August for immatures. Most captures of reproductive adults occurred from March to August, with significantly more captures in the spring than the summer. This suggests that breeding occurs primarily in the spring. Tailed frogs grew year-round with faster summer (1.22 mm/month) than winter (0.89mm/month) growth. Females grew significantly faster and to a larger maximum size than males. Growth curves indicated that following metamorphosis, females may reach sexual maturity in three years whiles males may become reproductive in two years.

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Fish, Pesticides and the Decline of Mountain Yellow-legged Frogs

Introduced fish and pesticides have both been implicated as contributing to population declines of a number of California amphibians. However, to date the fish and pesticides explanations for amphibian declines have not been assessed together within a single study. We examined the impact of fish and upwind pesticide use on population status of the mountain yellow-legged frog (*Rana muscosa*) at close to 7,000 water-bodies in California's Sierra Nevada, including almost all water-bodies in Yosemite and Sequoia-Kings Canyon National Parks and part of the John Muir Wilderness. At each site we collected information on presence/absence of R. muscosa and

introduced fish, water-body depth, elevation, substrate composition and number of nearby water-bodies. Upwind pesticide use from 1991 to 2000 was determined based on predominate wind directions and Department of Pesticide Regulation pesticide application records. To examine the possibility of topography sheltering sites from windborne pesticides, for each site we calculated the difference between the prevailing wind direction, and water-body drainage orientation. Using generalized additive model regression we found that introduced fish, upwind pesticide use and topographic sheltering were all significant predictors of R. muscosa presence, along with covariates for spatial location, depth, elevation, and number of surrounding water bodies. The impact of fish was consistent with earlier observational and experimental studies of fish effects on R. muscosa. We found a steep near linear decline in the probability of frog presence with increasing upwind pesticide use, with an almost complete absence of frogs at water-bodies with high upwind pesticide use.

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Crayfish Predation on Foothill Yellow-legged Frog (*Rana boylii*) Egg Masses in the Northern Sierra Nevada

As part of ongoing monitoring of foothill yellow-legged frog (*Rana boylii*) populations on the North Fork Feather River (Butte Co., CA) for Pacific Gas and Electric's FERC relicensing project, we employed an underwater video camera system to investigate the fate of *R. boylii* egg masses and tadpoles. A total of four egg masses and one tadpole group were monitored using an Aqua-Vu® underwater video system during two consecutive field seasons (2003-2004). Analysis of 442.5 hours of video revealed that the introduced signal crayfish (*Pacifasticus leniusculus*) prey upon *R. boylii* egg masses and contribute to premature detachment of egg masses from rocky substrates. Nine other species were observed near egg masses and tadpole groups, none of which were found to be significant predators of *R. boylii* during video monitoring. Visual encounter survey results suggest that signal crayfish also prey upon larval stages of *R. boylii*, based upon observations of tail injuries. Signal crayfish are present in large numbers in this drainage and have been observed in other systems where *R. boylii* are found, including the Pit and Stanislaus Rivers. Introduced crayfish may present a significant threat to Sierran *R. boylii* populations, where the species lacks evolutionary experience with crayfish predation. Future studies should address: 1) the extent of crayfish predation pressure 2) area of sympatry, and 3) developmental and behavioral effects of introduced crayfish on *R. boylii* populations.

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Pesticide Impacts on Amphibian Populations in the Sierra Nevada Mountains: Results of Field Studies and Laboratory Experiments

When an experimental translocation of *R. muscosa* in 1994 to 1995 was deemed unsuccessful in 1997, the last 20 translocated frogs were collected from the release site, and pesticide concentrations were measured at both the release site and a control site. DDE concentration in frog tissue was one to two orders of magnitude higher than the other organochlorines. Both g-chlordane and trans-nonachlor were found in significantly greater concentrations in frog tissue from the release site. Organophosphate insecticides, chlorpyrifos, and diazinon were observed primarily in surface water with higher concentrations at the release site. No contaminants were significantly higher in our control samples. Subsequent laboratory experiments using *Hyla regilla* and *Rana boylii* tadpoles have examined both acute toxicity and chronic effects of endosulfan and chlorpyrifos on growth and metamorphosis. Endosulfan was more toxic than chlorpyrifos, and endosulfan was more toxic to *R. boylii* than *H. regilla*. This work demonstrates that environmentally realistic concentrations of commonly used pesticides can have a impact on native amphibians in the Sierra Nevada Mountains.

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Complementary Resource Use and Migration Potential of Cascades Frogs (*Rana cascadae*): A Case Study in the Trinity Alps Wilderness, California

Ranid frogs of western North America are among the most seriously impacted of all amphibian species. In light of investigations documenting rapid declines of Cascades frogs (*Rana cascadae*), renewed attention has been placed on their conservation. *Rana cascadae* require at least three major complementary resources for annual activities: reproduction, foraging, and hibernation. As with many high elevation temperate anurans, *R. cascadae* are subjected to move seasonally because some or all of these resources are spatially and temporally separated, requiring migrations among and between habitat patches. In a high-elevation (2200m) basin within the Trinity Alps Wilderness, California, we used radio transmitters and PIT tags to characterize movements among and within habitat patches for all post-metamorphic life stages. Movements were documented across the entire activity period (June-September) for two years. We conducted 21 basin wide mark-recapture censuses which resulted in and 3726 captures for

post-metamorphic frogs. Adult frogs moved more on average (425.7 ∀ 37m SE), than juveniles (265.2 ∀ 23.7m). We collected 972 individual radio telemetry locations for 35 adult frogs. Mean 95% fixed kernel home range size was 1.14 ∀ 0.27 ha. Migrations occurred quickly between habitat patches and were not limited to aquatic corridors. Frogs occupied an array of aquatic habitats, but appeared to be selecting different types based on seasonal life history requirements.

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Antipredator Response and Palatability of Yosemite Toad Larvae to Nonnative Brook Trout in the Sierra Nevada Mountains of California (poster)

Introduction of non-native trout into fishless lakes in the Sierra Nevada Mountains of California has been shown to adversely affect some native frog populations through predation. The Yosemite toad (*Bufo canorus*), is also declining throughout its range in the Sierra; however, many tadpoles of the genus *Bufo* possess chemical toxins and are thought to be unpalatable to fish. Understanding the role of trout predation is critical to the proper management of this species.

To determine the effect of trout on Yosemite toads, I performed two experiments. In the first experiment, the antipredator behavior of Yosemite toad tadpoles in response to brook trout (*Salvelinus fontinalis*) chemical cues was measured by change in tadpole activity levels using a gravitational flow-through system. I predicted that if Yosemite toad larvae were susceptible to trout predation they would be able to detect trout chemical cues and respond through reduced activity levels along with increased refuge use. I found that Yosemite toad tadpole activity and refuge use did not differ significantly from controls.

In the second experiment, palatability of Yosemite toad larvae to brook trout was assessed by conducting choice experiments in which Yosemite toad and Pacific treefrog (*Hyla regilla*, a known palatable species) tadpoles were offered to starved trout. No Yosemite toad tadpoles were consumed by trout during the experimental trials, while trout consumed treefrog tadpoles readily. These preliminary results suggest that Yosemite toad larvae have retained chemical defenses even though they evolved in absence of fish predators. Although tadpoles were not consumed, there may be sublethal effects from trout "sampling" or mouthing and ejecting tadpoles, which was observed during trials.

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The Response of Amargosa Toad Populations to Habitat Change at Selected Sites

One of the key issues facing the Amargosa toad is vegetation growth. Spring pools and outflows that once harbored many toads have become choked with vegetation which has reduced reproduction, prevented toadlet migration from the springs, and provided ideal habitat for the colonization of nonnative predators. Vegetation has increased because of recently excluded grazing at spring sites, poor flood control measures, and water development. Habitat restorations in 2003 and 2004 have already yielded results at one site. The success of future actions at sites throughout the valley will depend on how long the newly restored habitats continue to function and how much human intervention will be needed to maintain proper function.

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Balancing the Operations and Maintenance Requirements of the State Water Project with the Habitat Needs of the Federally Threatened California Red-legged Frog: Can California Red-legged Frogs and DWR Operations and Maintenance Activities Co-exist? (poster)

In 1996 the California red-legged frog was listed as federally threatened, and all maintenance removals of sediment and vegetation in drainages flowing under the California and South Bay aqueducts within DWR's Delta Field Division ceased in order to prevent "take" of a listed species. Since all maintenance activities stopped, sediment load and vegetation growth within these drainages increased. Several permits needed to be obtained in order to proceed with the maintenance work at sites known or believed to contain these frogs. After receiving the permits, including a Biological Opinion from the U. S. Fish and Wildlife Service and a 1601 Programmatic Stream Alteration Agreement from the Department of Fish and Game, modified maintenance activities are now past their second year. The poster describes the maintenance activities and shows preliminary results of monitoring to determine whether or not these activities benefit the resident California red-legged frog populations.

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Implications of the Discovery of *Rana yavapaiensis* in the Western Grand Canyon to the Conservation Strategy for *Rana onca*

The minimum historical range of the relict leopard frog, *Rana onca*, comprises the drainages of the Virgin and Colorado rivers from the vicinity of Hurricane, Utah, to Black Canyon below Lake Mead, in Nevada and Arizona. Extant populations are known near only the Black Canyon and Overton Arm of Lake Mead. One adjacent area that may contain extant populations remains largely unsurveyed. This is the Colorado River and tributary drainages upstream from the confluence with the Virgin River (part of Lake Mead) in the western portion of the Grand Canyon. A few sites in this area were recently surveyed and a population of frogs physically similar to *R. onca* was found in Surprise Canyon (a tributary drainage). A mitochondrial DNA sequence analysis of several specimens showed that these individuals were more closely related to the lowland leopard frog, *Rana yavapaiensis*, than to *R. onca*. Surprise Canyon is situated within the Potential Management Zone (PMZ) for *R. onca*, as identified in the draft Conservation Assessment and Strategy (CAS). Discovery of the Surprise Canyon frogs within the PMZ has raised new concerns about the potential for hybridization. This threat impedes the primary recovery mechanism for *R. onca* identified in the draft CAS, i.e., to establish a number of new populations within the PMZ. Translocation sites are critically needed, but the majority of potential sites observed to date appear to be severely degraded. The western Grand Canyon was viewed as a promising area for establishing populations. Without further information, however, the threat of hybridization with the Surprise Canyon frogs renders questionable the suitability of this portion of the PMZ. The uncertainty is acute because the extent and identity of ranid frogs within the western Grand Canyon remains mostly unknown.

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Malformations and Parasite Infection: An Emerging Problem in Amphibian Conservation

Although malformed amphibians have been observed sporadically since at least the 1700s, reports of population-level, "mass malformations" have become increasingly common only since the mid-1990s. Here I present an overview of field and laboratory investigations into the causes and consequences of amphibian limb deformities. Field surveys throughout the western and midwestern USA indicate that trematode parasite (*Ribeiroia ondatrae*) infection is significantly associated with greater-than-baseline levels of malformations. Experimental exposures of frogs, toads and salamanders with realistic numbers of *Ribeiroia* cercariae demonstrate that infection causes malformations identical to those observed in field surveys, including supernumerary limbs (up to six extra), missing limbs, skin webbings, and bony triangles. Combinations of re-survey data, voucher specimen examinations, and interview data indicate that, while *Ribeiroia* infection is not a new cause of amphibian deformities, it may be on the rise. Current research is focused on secondary factors that interact with parasite infection to elevate the frequency of deformities. Field data suggest that wetland eutrophication (excess nutrient runoff) promotes infection and deformities through its effects on algal production and rams horn snails – the first intermediate host of *Ribeiroia ondatrae*. Although field and experimental data indicate that parasite infection and malformations increase mortality, there is as yet no research dedicated to long-term interactions between amphibian population declines and deformities. I argue that *Ribeiroia* infection and malformations will grow in conservation importance as natural wetlands and amphibian breeding areas are continually destroyed, forcing amphibians into suboptimal habitats conducive to the parasite's life cycle.

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California Department of Fish & Game High Mountain Lake *Rana muscosa* Habitat Restoration

In the late summer of 1999 CDFG began their first high mountain lake non-native trout removal project to recover native amphibians specifically, *Rana muscosa*, in the Big Pine Basin, Inyo County. This pilot project was funded as an experiment to determine the feasibility of fish removal in high mountain lakes using non-chemical methods. Upon successful trout eradication and amphibian resurgence in 2001, CDFG proposed additional vital native species restoration sites in an attempt at recovery of extant *R. muscosa* populations.

To date, CDFG (Eastern Sierra Inland Desert Region 6) has initiated native species restoration projects at 19 lakes. These 19 lakes will aid recovery of 9 *R. muscosa* populations. Of these 19 lakes, all but 2 have and/or are currently having non-native trout mechanically removed. Four management plans (Mt. Tom, Bishop Creek, Middle Fork San Joaquin, and West Walker) pending approval, propose another 20 native species restoration areas, in all tallying 70 lakes.

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How Useful Is Tadpole Mouthpart Depigmentation as an Indicator of Chytridiomycosis?

Chytridiomycosis is a disease caused by the amphibian chytrid fungus, *Batrachochytrium dendrobatidis*. This disease has been implicated in the decline or extinction of many amphibian populations worldwide and as a consequence, there is considerable interest in inexpensive methods for accurately determining the chytrid status of amphibians. Depigmentation of tadpole mouthparts (i.e., jaw sheaths and toothrows) is a commonly cited outcome of chytridiomycosis, but no effort has yet been made to determine the accuracy of mouthpart depigmentation as an indicator of chytridiomycosis. We conducted such an analysis using mountain yellow-legged frog (*Rana muscosa*) tadpoles collected in California's Sierra Nevada. For 118 tadpoles whose mouthparts spanned the complete range of depigmentation (from fully pigmented to completely depigmented), we determined actual chytrid status of individuals using PCR tests. Depigmentation of jaw sheaths and toothrows were both related to tadpole chytrid status, and this relationship was particularly strong for upper jaw sheaths. Of the 64 tadpoles that showed any depigmentation of the upper jaw sheath, 54 (84%) were chytrid-positive. Of the 52 tadpoles that had fully pigmented upper jaw sheaths, 46 (88%) were chytrid-negative. Based on these results, we suggest that inspection of tadpole mouthparts for evidence of depigmentation is an easy and accurate method of determining the chytrid status of *R. muscosa* populations.

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Status, Decline, and Phylogeography of *Rana boylii*: Implications for Conservation of Frogs and Rivers

The foothill yellow-legged frog (*Rana boylii*) is a stream-associated frog that is declining over much of its historic range in California and Oregon. This paper summarizes recent research on likely decline factors and provides the first range-wide phylogenetic and population genetic analyses for this species. For analysis of decline factors, we used univariate and multivariate analyses to examine the spatial relationship between the current status of *R. boylii* (present or absent) at historic localities relative to: geographic characteristics (e.g. elevation and latitude), land use impacts, wind-borne toxins and pollutants, climatic factors, and proximity and size of dams. Climatic affects were the strongest of any individual variable as well as showing strong influence in multivariate models. Specifically, mean annual precipitation was positively related to presence and variability of precipitation and percent of dry years were negatively related to presence. We also discovered evidence for interactions, especially that negative effects of dams appear to be exacerbated in areas with low precipitation. It appears that *R. boylii* is responding to recent climate changes and thus conservation efforts must consider the implications of this factor in the future. For genetic analyses, we used 1525 total base pairs from sequences of two mtDNA fragments (Cytochrome B and ND2) for 77 individuals from 34 localities. Our results demonstrated that several well-supported geographically congruent clades exist within *R. boylii*. While genetic variation was low among populations in the largest, most inclusive clade, individuals from several localities demonstrated substantial genetic divergence. Hydrologic regions, which represent likely dispersal corridors for *R. boylii,* show promise in explaining historic patterns of genetic variation and may be the appropriate units for conservation as well.

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California Department of Fish & Game High Mountain Lakes Database

California Department of Fish & Game (CDFG) has completed its fourth year of the High Mountain Lakes (HML) project. The project's goals are to inventory all mapped water bodies and unmapped water bodies with biological resources in the high country of the Sierra Nevada excluding lakes within National Park boundaries. Data collected at each water body included habitat characterization, a census of frog and toad species present, and a gill net sample of fish populations present. Currently, out of an estimated 10,750 lakes to be surveyed, 7607 have been inventoried. Significant amphibian findings include 558 sites with *Rana muscosa*, 267 of which supported larvae, and 161 sites with *Bufo canorus*. That out of the 558 sites with *R. muscosa* only 81 are known to coexist with fish is particularly poignant to the recovery of the species. Lakes inventory data is used to develop Aquatic Biodiversity Management Plans for each watershed that establishes management directions for recreational angling, amphibians and other native species.

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A Skeletochronological Study of the Longevity and Age Structure of the Mountain Yellow-Legged Frog, *Rana muscosa*, in the Sierra Nevada, California

We used skeletochronology to age 149 (67 females, 44 males, and 38 metamorphs) mountain yellow-legged frogs, *Rana muscosa*, from 13 locations throughout their current range in the Sierra Nevada. Lines of arrested growth (LAGs) from excised toe bones were distinct in these high elevation frogs and each LAG was assumed to represent one year of age. Females ranged in age from 0-10 years (mean = 4.4 years) and males from 0-8 years (mean = 4.0 yrs). The skeletochronological age was that of the adult frog, and did not include the tadpole stage. Mountain yellow-legged frogs spend 3-4 years as tadpoles, thus, their total ages including both tadpoles and adult stages ranged up to 14 years. Ages from sample sites at higher elevations (n=5 sites >3000 m) had the broadest range up to 10 years. In comparison, ages from sample sites at lower elevations (n=8 sites <3000 m) ranged up to 7 years. However at lower elevations, length and weight at age was higher. Mean masses and lengths of frogs were greater from those sampled < 3000 m (n= 83, mean mass = 29.8 g, mean length = 60.4 mm) compared to those > 3000 m (n=66, mean mass = 14.8 g, mean length 47 mm). Compared to other ranid species, mountain yellow-legged frogs were found to be relatively long-lived and which has implications for restoration and recovery plans. We found that location (elevation and location within the

northern-southern Sierra Nevada range) was an important variable in the relationship between length and age.

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Creating pond habitat for Columbia spotted frogs in the Reese River drainage, Central Nevada

A conservation agreement and strategy (CAS) was signed in September 2003 for Columbia spotted frog (*Rana luteiventris*) populations in Nevada. One of the objectives of the CAS states that viable populations and their habitats are managed and enhanced to ensure the continued existence of Columbia spotted frogs throughout their historic range in Nevada. During the summer and fall of 2004, a multi agency effort began to monitor populations of Columbia spotted frogs in the Reese River drainage. In addition to the monitoring effort, pond habitat was created and/or enhanced along a tributary to the Reese River. Effectiveness monitoring will begin in 2005 to assess the desired outcomes of the project.

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California Department of Fish & Game Management of Native Fauna and Introduced Fisheries in Sierra Nevada Lakes

Using comprehensive and current data on fish and herpetofauna distributions within watershed-based management units, the California Department of Fish and Game is developing management plans to restore native aquatic faunal assemblages while meeting reasonable expectations for recreational angling. Native fauna restoration projects focus on key amphibian species, usually the mountain yellow-legged frog, *Rana muscosa*, with the measure of success being the reestablishment of large naturally functioning ecosystems that provide habitats for the continued evolutionary development of native fauna. Native species restoration projects, usually in the form of fish removals, are being proposed and implemented across the Sierra Nevada where feasible from biological, physical and political perspectives. Where recreational angling is identified as the management direction, fisheries managers utilize new and traditional means, including aerial fish stocking, to meet management objectives. Interestingly, fish removal projects and fisheries management activities have been funded through Federal Sport Fish Restoration Act and other state and federal funding sources.

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Habitat Variability Observed at Foothill Yellow-legged Frog (*Rana boylii*) Breeding Locations in Several Large River Drainages along the West Slope of the Sierra Nevada: Implications for Developing Survey Strategies

Available literature on habitat preferences of foothill yellow-legged frog (*Rana boylii*) in large river systems in Northern California has been derived primarily from research on coastal rivers. These studies have documented *R. boylii* utilizing wide, shallow reaches with cobble and boulder river bars and/or side channels for breeding. Until recently, very little information on R. boylii habitat was available for Sierra Nevada populations. However, within the last five years, numerous hydroelectric relicensing projects along the west slopes of the Sierra Nevada have required detailed studies to evaluate *R. boylii* populations relative to project operations. As a result, extensive surveys have been conducted on several large river systems in the Sierras including the Mokelumne, Stanislaus, American, and Feather rivers. Results of these studies indicate that *R. boylii* populations in the Sierras appear to utilize a wide variety of habitats for breeding. Drainage specific differences in channel morphology and substrate composition can significantly affect the types of habitat utilized by this species. *R. boylii* appear to be highly adaptable to a variety of habitat types when "traditional" habitats (e.g., cobble/boulder bars, side channels) are not available, or in response to altered flow regimes on regulated rivers. Consequently, when designing studies in the Sierras, the selection of survey sites should include a relatively wide array of habitat types, especially if traditional breeding habitat is in limited supply, or if the seasonal flow regime is altered or regulated by dams or hydroelectric projects.

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Calaveras Red-legged Frogs Make A "Celebrated" Comeback

In late 2003 on a ranch in Calaveras County, two small children playing near an isolated pool along an intermittent creek discovered a population of California red-legged frogs (*Rana draytonii*). The Jumping Frog Research Institute (JFRI) preliminarily identified the species in

October 2003, and biologists from the US Fish and Wildlife Service (USFWS) subsequently confirmed the find with a night-time survey that revealed three adults.

Through 2004, the children, who were enlisted as "junior biologists"in the effort, actively surveyed and monitored the site. Breeding was documented in an upstream in-channel pool in March 2004, but non-native green sunfish (*Lepomis cyanellus*) threatened to rapidly consume the entire complement of larvae resulting from the only egg mass found. Approval was sought and granted by the USFWS to begin an active seining and gill netting program to reduce or eliminate the fish from the creek reach up- and downstream of the known tadpole locations.

By late Summer 2004, recruitment of over 50 juvenile California red-legged frogs had been documented, and the landowner has voluntarily agreed to undertake a series of habitat improvements suggested by JFRI and the USFWS that should further enhance the survival and recovery of what is widely believed to be Mark Twain's "Celebrated Jumping Frog of Calaveras County."

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Projected Effects of Upland Habitat Loss on California Tiger Salamander Populations - Lessons for Conservation Planning

Many amphibians breed in wetland habitats, and spend the vast majority of their lives in nearby upland habitats. However, for most species the spatial distribution of individuals in upland habitat is poorly understood. To estimate the upland distribution of subadult and adult California tiger salamanders (*Ambystoma californiense*), we used a novel trapping approach that allowed us to model the spatial variation in capture rates in the landscape surrounding an isolated breeding pond. As expected, we found that captures of adults declined with distance from the breeding pond. However, captures of subadults climbed steadily from 10 to 400 m from the breeding site, but declined to zero at 800 m. A negative exponential function fit to the adult capture data suggested that 50, 90, and 95% were within 150, 490, 620 m of the pond, respectively. For subadults, the quadratic function fit to the data similarly suggested that 95% were within 630 m of the pond, but that 85% of this life stage was concentrated between 200 and 600 m from the pond. To investigate the population-level consequences of reducing the amount of suitable upland habitat around breeding ponds, we used a stage-based stochastic population model with subadult and adult survival parameters modified according to our empirical observations of upland distribution. Model simulations suggested that substantial reductions in population size are less likely if upland habitats extending at least 600 m from the pond edge are maintained. Model elasticities indicated that quasi-extinction probabilities are more sensitive to reductions in subadult and adult survivorship than reproductive parameters. Understanding the upland ecology of pond-breeding amphibians, especially the distribution and survivorship of subadults is critical for designing protective reserves and land use plans.

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Can *Batrachochytrium dendrobatidis* Survive in the Environment Without an Amphibian Host? Preliminary Results from a Field Experiment with *Rana muscosa*

Amphibian declines are occurring worldwide and many potential causes have been identified, yet there is still little known about the relative importance of various factors in population declines. In the Sierra Nevada, California, the mountain yellow-legged frog (*Rana muscosa*) has suffered large declines, and several factors may be affecting populations. Recently, an emerging infectious disease, chytridiomycosis, caused by the chytrid fungus *Batrachochytrium dendrobatidis* has been identified in wild populations. In the past 3 years, *B. dendrobatidis* has spread in *R. muscosa* in the Sierra Nevada, and many infected populations have gone locally extinct. This study examined whether the persistence of *B. dendrobatidis* outside its host, *R. muscosa*, would preclude frog re-introductions to these sites. In order to understand whether *B. dendrobatidis* can survive without the host, we introduced uninfected tadpoles into host extinction sites associated with chytridiomycosis. Tadpoles from two uninfected source populations were re-introduced into 5 sites, each site contained two large cages (2m x 1m x 1m) with 30 tadpoles. We had one positive control (uninfected tadpoles added to a lake with an ongoing infection) and two negative controls (uninfected tadpoles transported and placed back into source lake inside cages). We collected the tadpoles after 10 weeks of exposure and used real-time PCR to determine if they were infected with *B. dendrobatidis*. At this time, about 70% of the samples have been analyzed, and so far, tadpoles from extinction sites (n=5) did not become infected. Our negative controls (n=2) were all uninfected; however, in our positive control (n=1 site; 60 tadpoles) all but one tadpole was infected. These results suggest that *B. dendrobatidis* may become extinct in the absence of a host.

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The Relationship of Cold-water Tributaries to Landscape-scale Attributes in a Northern California Watershed: Implications for the Conservation of Cold-water Adapted Amphibians

We examined relationships between stream temperatures and environmental attributes, including forest cover, in the Mattole watershed of northwestern California. We characterized temperature regimes of 40 tributaries by determining the highest maximum weekly maximum temperature (MWMT) using measurements recorded every hour throughout the summer. Multi-year sampling established a link between cold-water tributaries (MWMT $\leq$18 ^{o}C) and the presence of two headwater amphibian species of special concern, the tailed frog and southern torrent salamander, and the threatened coho salmon. While our analysis indicated that stream temperature was the best predictor of the presence of these cold-water-adapted species, the best predictor of stream

temperature regimes was a landscape-scale model consisting of three variables: aspect, catchment area, and proportion of non-forested habitat ($R^2 = 0.69$). Temperature regimes in the warmest tributaries containing these species, combined with historic and current watershed conditions which affect stream temperatures, suggest that strategies to restore and conserve cold-water species in this and similar watersheds, should focus on managing for lower stream temperatures. According to our model, the best variable available to effect a particular water temperature regime is the amount of intact forest cover. Sensitivity analyses based on this model indicated that if the objective is to provide summer stream temperatures suitable for tailed frogs, torrent salamanders, or coho salmon in a north-facing basin of 400 ha, forest cover should be maintained at $\geq$85%.

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Mating System and Strategy of the Foothill Yellow-legged Frog (*Rana boylii*).

Due to recent declines across its historic range the foothill yellow-legged frog (*Rana boylii*) is currently the subject of many ongoing research projects. However, aspects of the species natural history are still largely unknown. Our objective was to obtain information about the species mating strategy by studying a breeding population in a natural and static breeding location. Understanding the mating strategy provides information on effective population size and genetic diversity of a breeding population. We monitored breeding activity and collected data on observations during three breeding seasons. Our recapture data indicate that individuals have site fidelity to breeding areas. Daily sex ratios were highly male-skewed. Breeding season sex ratios were female-skewed. We found a negative association between male size and arrival time to the breeding area in 2002 and 2003 (Pearson, r=-0.66 and r=-0.38, respectively). We found no relationship between male size and site tenure in 2002 or 2003 (Pearson, r=0.09 and r=-0.12, respectively). Our 2003 data suggests that there is no size-assortative mating (Pearson, r=0.13, P =0.53), however females may be selecting larger males (T-test, T=2.35, df=27, P=0.03). Our observations indicate that male frogs are maintaining and aggressively defending territories within the breeding area. Males arriving earlier to the breeding site maintained smaller territories (Pearson, r = 0.51), males maintaining larger territories are more aggressive (linear regression, r^2=0.37), and aggressive males have a higher frequency of calling (Pearson, r=0.47). These results indicate that this breeding population exhibits a complex mating system and social structure.