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ABSTRACTS

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Breeding Phenology of the Foothill Yellow-legged Frog (*Rana boylii*) in the Trinity River Basin, Surveys from 2004-2007

Flow regimes are measured for magnitude, frequency, duration, timing and rate of change. These parameters can act as proximal cues to influence when native biota reproduce. The foothill yellow-legged frog (*Rana boylii*) is one such species occurring in the Trinity River Basin that typically breeds in large river systems in the spring. We conducted breeding surveys on the Mainstem, North Fork and South Fork Trinity Rivers in 2004-2007. In addition to breeding surveys, in 2006 and 2007, we tracked the breeding phenology, size of larvae, and time and size to metamorphosis of foothill yellow-legged frogs. Surveys conducted from Douglas City to the confluence of the North Fork Trinity River yielded 26, 12, 7 and 7 egg masses in 2004, 2005, 2006 and 2007, respectively. In one mile of reach on the lower North Fork Trinity River, we detected 69, 72 and 55 egg masses in 2004, 2005 and 2006, respectively. For an approximate 10 mile reach on the South Fork Trinity River, we detected 62, 852, 489 and 510 egg masses in 2004, 2005, 2006 and 2007, respectively. Breeding phenology is discussed in relation to flows and temperatures between these three rivers, as well as their influence on larval growth parameters in 2006 and 2007.

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Breeding Phenology of the Northern Red-legged Frog (*Rana aurora*) at Humboldt Bay National Wildlife Refuge, California, USA

Developmental stages, specifically egg masses are an excellent life stage to study breeding biology due to their static nature. The northern red-legged frog (*Rana aurora*) has received little attention in California despite its relatively constricted range and numerous potential population stressors. We studied the breeding phenology of the northern red-legged frog at Humboldt Bay National Wildlife Refuge from November 2006 to April 2007. Surveys were conducted 1-2 times per week for a total of 23 survey efforts over 21 weeks. Oviposition microhabitat data and abiotic information was collected at each egg mass location. Egg masses (N=237) were individually monitored and their fate was determined. Our results suggest that northern red-legged frogs have a prolonged breeding season that exceeded three months (1st egg masses seen on December 17, 2006 to last egg mass seen on March 25, 2007). However, an explosive breeding event (82 new egg masses in three nights) in February, following four weeks of limited production, suggests these frogs are using environmental cues to oviposit egg masses during favorable conditions. These results will contribute to the baseline knowledge of the northern red-legged

frog in California and assist resource managers in making informed decisions to best conserve this species.

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Ongoing Restoration of Mountain Yellow-legged Frogs and High Mountain Lakes and Streams in Sequoia and Kings Canyon National Parks, California

Since 2001 Sequoia and Kings Canyon National Parks have been eradicating non-native trout from naturally fishless high mountain lakes to restore habitat for native fauna, with an emphasis on improving the status of imperiled mountain yellow-legged frogs (*Rana muscosa, Rana sierrae*). These frogs were once common inhabitants of high Sierra Nevada lakes, but have disappeared from about 94% historic localities, largely due to the widespread introduction of trout and recently due to chytridiomycosis. To date we have removed nearly 23,000 trout, restored nine lakes and are close to restoring two additional lakes. Frog densities measured in the nine restored lakes showed an average 14-fold increase between 2001 and 2007, while one lake showed a 60-fold increase. The biomass recovery in these lakes has attracted native predators, such as snakes, birds, and even mammals, which have been observed preying on the now-abundant frogs, tadpoles, and aquatic invertebrates. Due to this success, SEKI recently conducted public scoping to expand restoration to additional lakes and streams across these parks. Scoping results showed broad public support for additional restoration. Although chytridiomycosis has recently extirpated or impacted many mountain yellow-legged frog populations in the Sierra Nevada, a few abundant populations occupying fishless sites have survived and reproduced after becoming infected. This finding further supports the importance of continuing to eradicate non-native trout from high mountain lakes.

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Spatial Patterns of Airborne Pesticides in the Alpine Habitat of a Declining California Amphibian, the Mountain Yellow-legged Frog

The mountain yellow-legged frog complex (*Rana muscosa* complex) has disappeared from most of its historic localities in the Sierra Nevada of California, and airborne pesticides from the Central Valley have been implicated as a causal agent. To determine the distributions and concentrations of pesticides in the habitat of this species, we sampled air, sediment, and Pacific treefrog *(Pseudacris regilla)* tadpoles at high elevation (2754-3378 m) throughout Sequoia and Kings Canyon National Parks. Twenty-eight sites were sampled (14 dispersed areas, 2 ponds/area) twice during summer of 2005. Passive air sampling devices, which sampled air over 30-d intervals, detected only the pesticide endosulfan II frequently. In sediment and tadpoles, we found nine pesticides or their breakdown products frequently: the currently used endosulfan (I & II), endosulfan sulfate, dacthal, and chlorpyrifos, and the historically used DDE, chlordane (trans), and nonachlor (cis & trans). Concentrations were low, a few ng/g dry mass (ppb) or less for sediment and tadpoles. Pesticide distributions showed a general decrease in concentration with

distance from agricultural areas in the Central Valley (43-82 km away), but Pearson r^2 values were low. A preliminary analysis of the distribution of pesticides relative to the distribution of remaining populations of mountain yellow-legged frogs does not show a correspondence between the two.

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Monitoring Amphibians: Can't I Just Start Counting Frogs?

Currently, there are many ongoing programs for monitoring amphibian species and communities that vary widely by scope, methodologies used, and effectiveness. In addition, statistical applications for these purposes are rapidly evolving. We review a basic process and key considerations in devising a meaningful monitoring program from first asking the basic question "Why monitor?" to writing up a thorough protocol. What life stage to monitor is a common issue. We also address the dilemma of choosing occupancy vs. abundance by considering species life history traits and the ability to evaluate effects of stressors and management actions on amphibian populations. Once created, amphibian monitoring protocols should contain detailed information on how to choose samples, perform field surveys, record & store data, specific data analyses, trend metrics, and critical levels for management action. It's not over yet! They need to be re-evaluated on a periodic basis to determine if initial assumptions were valid and if program goals are being met. We use some past and current amphibian monitoring programs as examples throughout.

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Spatial Dynamics and Habitat Factors of California Red-legged Frogs

A clear understanding of the spatial dynamics and habitat factors that govern the distribution of a species is critical for effective conservation and management strategies. With a strong grasp of these factors, land managers can optimize conditions for species of concern and possibly make conditions unsuitable for invaders. We conducted two studies on amphibians in the Elkhorn Slough watershed of central California. The first focused on the factors correlated with amphibian distribution of the common native Pacific chorus frog, the threatened native California red-legged frog, and its invasive congener, the American bullfrog. We found differences in the relationships of these species to factors such as poor water quality, degree of isolation, and proximity to roads, and we hypothesize that sensitivity to these factors may contribute to which species decline. In addition, our work suggests that distribution of amphibian species may be affected by interactions of physical conditions with biological variables, namely the presence of other species. In our second study, we conducted a mark-recapture study of California red-legged frogs to understand their spatial dynamics. We investigated the potential for frogs to go extinct in a pond, pond characteristics correlated with extinction, and factors affecting movement between ponds. We used this information to test whether California red-legged frogs at met the conditions of a metapopulation. When analyzed at the level of a single site with ponds, California red-legged frogs acted as a patchy population rather than a true metapopulation, but they may act as a metapopulation when multiple sites are connected within a broader region.

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I**mpacts of Post-fire Geological Processes on Amphibian and Fish Habitat in Southern California**

Fall firestorms in southern California are becoming more common and the burn areas often now include entire watersheds. Several amphibians in southern California are very rare or almost extirpated and they may have localized populations within specific watersheds. USGS has been developing a series of predictive models to predict the volume and probability of debris flows following burns as tools for reducing risk to life and property under various precipitation scenarios. We evaluate these models as they relate to amphibian and fish habitat and document the physical processes that take place following watershed burning from our recent observations. We also discuss recent data about ash from the 2007 firestorms as it potentially relates to distributional patterns observed in salamanders following the 2003 firestorms. Active management through extreme measures may be required in some instances to salvage populations until ecological resilience is restored in the southern California landscape.

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Determining the Susceptibility of Springs and their Associated Anuran Communities in the Mojave Desert to Climatic Change and Development.

From 2005-2006, USGS Western Ecological Research Center (WERC) and USGS California Water Science Center (CWSC) worked jointly to collect baseline aquatic and biotic data at selected springs within Death Valley National Park (DEVA), Mojave National Preserve (MOJA), and Joshua Tree National Park (JOTR). The project was initiated by the Inventory and Monitoring program of the National Park Service to assess the susceptibility of these springs and their associated anuran communities to water quality and quantity impacts resulting from anthropogenic and climate changes. The anuran species studied were the western toad (*Bufo boreas*) at DEVA, the red-spotted toad (*Bufo punctatus*) at MOJA and JOTR, and the California treefrog (*Pseudacris cadaverina*) at JOTR. The study revealed that the site most susceptible to climatic changes was 49 Palms Oasis (JOTR), due to the young age of the water as indicated by Carbon 14 and Tritium age dating methods. Both Darwin Falls (DEVA) and Piute Spring (MOJA) were found to have relatively old water and therefore not dependent on climatic fluctuations for water. However, anthropogenic factors from water diversion could pose future problems to the western toad population and its distribution at Darwin Falls. Red-spotted toads at Piute Springs showed elevated abnormality rates (0.056, $n = 678$) and the presence of *Batrochochytrium dendrobatidis* (Bd), and the frog and toad populations at 49 Palms Oasis showed a large decline (~50%) from the early 1970's estimate, as well as the presence of Bd in red-spotted toads.

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Status of Relict Leopard Frog Conservation

Once thought to be extinct, remaining Relict Leopard Frog (*Rana onca*) populations are now covered under a conservation agreement and strategy (CAS) between federal and state entities. The CAS is managed by a voluntary conservation team and stipulates management goals and actions, including implementation of a translocation program and semiannual surveys. We provide an update on the status of management actions for this species. Since 2003, 7 experimental populations have been established. Two of these populations have failed because of water loss, 2 contain over-wintering adult animals and evidence of breeding, and 3 show evidence of repeated breeding and recruitment to adult stages. Two new translocation sites are expected to be added in 2008, however, most potential translocation sites within the established management zone for this species are of poor habitat quality for Relict Leopard Frogs and acceptable sites are limited. A storm event in October 2006 caused floods and debris flows through sites containing natural populations within Black Canyon. The largest population suffered a substantial reduction in number, and habitat quality and quantity at the site was substantially reduced. This same storm event may have improved habitat at other sites in the canyon by scouring out dense vegetation and creating pools. Populations along the Northshore of Lake Mead appear to have declined, possibly because of riparian vegetation encroachment into more open habitat following burro reduction efforts. Experimental mechanical vegetation reductions, controlled burning, and creation of fish-free breeding ponds have been used in attempts to improve habitat conditions at these sites.

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Development of Habitat Suitability Criteria for the Foothill Yellow-legged Frog (*Rana boylii*) in the Northern Sierra Nevada, and Coast Ranges of California

The condition and suitability of key habitat elements is one component of status assessments for species at risk. The foothill yellow-legged frog (*Rana boylii*) inhabits a variety of lotic ecosystems, many of which have undergone substantial alteration of hydrologic regimes as a result of water storage, diversion, and hydroelectric power generation projects. Because of its declining status, *R. boylii* has become a focal species in recent Federal Energy Regulatory Commission (FERC) re-licensings of hydroelectric projects. In addition to direct population monitoring, habitat assessments and instream flow modeling are being conducted for *R. boylii* and other aquatic species during FERC re-licensings in California. Using pre-existing data from four Sierra Nevada and one Coast Range river, we developed suitability criteria for three aquatic habitat variables (water depth, water velocity, and substrate) for pre-metamorphic life stages (egg masses and tadpoles) of *R. boylii*. We focused on egg masses and tadpoles because of the ample existing data and because effects of changes in hydrologic regimes and river habitats were thought to be more severe for these highly aquatic life stages. Three suitability levels (high, marginal, and not suitable) were developed for each life stage and habitat variable. These levels were based on the range of water depth, water velocity, and substrate values observed for 90%, 10%, and 0% of egg masses or tadpole groups, respectively. Consistent with previous natural history accounts and studies, shallow water, slow water velocity, and large substrates represented the highest suitability. These criteria will ultimately be used in a 2-dimensional hydrodynamic model to determine habitat suitability at a variety of water flow

release levels for particular river reaches. Next steps are to validate the criteria in other rivers and to explore the development of similar criteria for post-metamorphic life stages.

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California's High Mountain Lakes Project – Status and summary of statewide surveys

The large-scale California Department of Fish and Game (CDFG) High Mountain Lakes Project began in 2001 to enhance assessment and management of California's high elevation aquatic resources. This presentation will describe the extent of surveyed waters and summary results from 2001 through 2007.

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Zoological Institutions and Native Amphibian Conservation in the Southwestern United States: Taming Conservation Problems in the Wild West

Herpetological conservation by zoological institutions in the United States has historically excluded native species – tending to focus instead on species from outside their ecological region. More recently, zoological institutions have made greater effort to become involved in both amphibian and reptile conservation with native species. The increasing number of formalized amphibian programs that zoos and aquariums have developed evidences this effort. The majority of Zoos in North America now support local/native amphibian conservation programs directly with financial support, public displays, education and outreach programs, funding for field research, etc. The Association of Zoos and Aquariums' (AZA) partnership with the World Association of Zoos and Aquariums' (WAZA) and with International Union for the Conservation of Nature (IUCN) have declared 2008 to be the "Year of the Frog." In keeping with this, accredited institutions are rallying to increase their participation in amphibian conservation. Evidence is provided of the successes and shortcomings of past and present projects that have involved the Zoological Society of San Diego and other regional institutions, in partnership with outside organizations. As future conservation efforts for amphibians gain visibility, and partnering opportunities increase, it is hoped that the lesson learned from past actions will be referenced to yield the greatest potential for amphibian conservation efforts. Recommendations are made for all parties who are considering collaborating or supporting zoological institutions as more active participants in cooperative local species amphibian conservation programs.

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Site Fidelity of *Rana muscosa*, the Mountain Yellow-legged Frog, in a High Elevation Basin in the Sierra Nevada

From 1997-2006, we used mark-recapture (passive integrated transponders) to determine the site fidelity of 1250 mountain yellow-legged frogs (*Rana muscosa*) in the water bodies of Dusy Basin, Kings Canyon National Park during their three main activity periods of overwintering, breeding, and feeding. From the 6865 recaptures, mountain yellow-legged frog were found in different water bodies throughout the active

period: during overwintering and breeding, frogs were primarily found in five main water bodies, but during feeding periods, frogs were more widely distributed throughout the basin and were recaptured in most water bodies. To quantify site fidelity, the tendency to return to and reuse previously occupied habitats, we used multi-strata models (with water bodies as the strata) and potential function analyses. We estimated movement probabilities between the water bodies and found that the probability of returning to previously used water bodies during all activity periods was typically greater than 80%, and always greater than the probability of moving to other water bodies. Models with lake specific movement transitions (site fidelity) were favored over those that held movement transitions equal between lakes. Potential function analyses demonstrated that frogs were most strongly attracted to wherever they had been originally captured rather than simply moving to the nearest available breeding or overwintering lake. Under current conditions in high elevation Sierra lakes, site fidelity is problematic because frogs are returning to reuse degraded habitats, those with exotic trout and those subject to lake drying.

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Experimental Aquatic Restoration in Yosemite National Park to Inform Aquatic Management and Recover the Sierra Nevada Yellow-legged Frog

Restoration of aquatic ecosystems was initiated in Yosemite National Park in 2007 on an experimental basis. The investigation is designed to inform development of a future Yosemite aquatic management plan that will emphasize the recovery of the rapidly-declining Sierra Nevada yellow-legged frog, *Rana sierrae*. In the study design, three sites contain *R. sierrae* in the watershed and frogs are expected to naturally recolonize the restoration sites. Three additional sites are in watersheds that no longer contain *R. sierrae*, necessitating translocations from source populations outside the watershed in attempt to restore frog populations. All six sites are currently devoid of *R. sierrae*, but are populated by non-native fish that prey on the frogs. No native fish occur at these sites. Non-native fish removal was initiated at four of the six sites in 2007 using physical techniques. Of these sites, two had low fish abundance, narrow age class distributions, and natural fish barriers, and nearly all fish were removed. Based on our 2007 experience, the restoration techniques appear feasible at the selected sites. Substantial differences exist among lakes in fish species, fish size, population size, and age class distribution, as well as in lake size, depth, spawning habitat, creek flow, fish barriers, and elevation, all factors influencing the effectiveness of fish removal. Amphibian and bird diversity data were collected at restoration sites to assess ecosystem response. The investigation is expected to be completed by 2010. This experimental restoration is being conducted in the presence of the nearly ubiquitous and highly virulent *Batrachochytrium dendrobatidis* fungus in *R. sierrae*, although some Yosemite populations are showing persistence. This adds an element of uncertainty to the success of future aquatic restoration in Yosemite.

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Columbia Spotted Frog Age-Growth Rates and Annual Population Fluctuation (or) Why an Agency Biologist Should Care

Three Districts of Humboldt-Toiyabe National Forest in NE Nevada support populations of Columbia spotted frog (Great Basin Population), a Candidate species. Monitoring sites, one per District, were

established in 2004 and 2005 to better understand local characteristics of this frog. Monitoring includes PIT tagging and elastomer marking for mark-recapture. Presented is a selection of results through 2007 concerning age-growth rates and annual population fluctuation. The importance of this data is discussed in relation to management implications.

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California's High Mountain Lakes Project – Management planning, Amphibian Restoration, and Fish Stocking

This presentation will update progress on CDFG's high elevation aquatic resources management planning, Sierra Nevada amphibian restoration work, and CDFG's fish stocking EIR; and report the decision on a recent lawsuit challenging CDFG's state-wide fish stocking program.

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Banking Amphibian Genetic Resources for Research and Recovery

Bioresource banking supports *in situ* and *ex situ* conservation efforts by facilitating research programs, through curation of samples for ongoing and future investigations and for potential assisted reproduction efforts. The Zoological Society of San Diego's collections of viable, frozen, early passage diploid cell cultures — known as the Frozen Zoo® — currently contains frozen cell cultures from more than 8,300 individual vertebrates comprising greater than 600 species. Only two of these species are amphibians, and to our knowledge, no systematic effort is underway to preserve important bioresource materials for characterizing amphibian populations, identifying factors associated with susceptibility and resistance to chytrid infection, small population management applications, and other studies crucial to efforts to achieve long-term sustainability of endangered amphibian populations. Small population management efforts for endangered taxa routinely generate questions amenable to analysis with genetic studies, including phylogenetic systematics, population genetics, patterns of migration and dispersal, kinship and parentage confirmation. Furthermore, studies of host-parasite interactions typically involve utilization of well-defined *in vitro* systems for elucidating mechanisms of pathogenesis and therapeutic intervention. The establishment of a network for collecting specimens suitable for establishment of cell cultures, and making resources (including derivatives such as DNA and cellular RNAs) available to the larger research community, is a crucial emerging need in support of long-term conservation efforts. The Amphibian Ark is supporting this conservation-focused resource by helping with the development and distribution of protocols for collection and storage of samples from the field.

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What's hopping in PARC and Southwest PARC (and opportunities for collaboration)?

Partners in Amphibian and Reptile Conservation (PARC) is a proactive, solutions-oriented partnership dedicated to encouraging collaboration between scientists, managers, and laypeople to achieve its mission of amphibian, reptile, and habitat conservation. The year of 2007 was demonstrative of the utility of our partnership, both nationally and in the Southwest regional working group (SWPARC). In February, PARC assisted the US Geological Survey to plan and secure sponsors and participants for a 3-day workshop entitled, "Understanding Agriculture's Effects on Amphibians and Reptiles in a Changing World." At the end of May, SWPARC held its first annual regional meeting in Albuquerque, NM, with over 100 people in attendance from across the region. In November, PARC and US Fish & Wildlife Service, along with partners, worked together to put together the "Amphibian Declines and Chytridiomycosis: Translating Science into Urgent Action" conference. Over 200 scientists, land managers, fisheries biologists, and representatives from the Pet Industry from 8 countries across 4 continents met to discuss the amphibian chytrid fungus, *Batrachochytrium dendrobatidis.* In December, a final draft of PARC's Strategic Plan was created, detailing our goals and how we hope to achieve them. We will present highlights from these and other projects occurring in PARC on the national and SWPARC fronts, including ways in which we hope to collaborate more closely with the CA/NV Amphibian Populations Task Force in the coming years.

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Science and Management of the Amphibian Chytrid Fungus, *Batrachochytrium dendrobatidis*

The emerging infectious disease *Batrachochytrium dendrobatidis* (= *Bd*) is an aquatic fungus affecting amphibians worldwide. *Bd* experts convened in Tempe, Arizona, in November 2007, to consolidate recent science findings and develop recommendations for management. Our understanding of the scope of *Bd* is advancing due to the global *Bd* mapping project: *Bd* sampling has occurred or is ongoing in 86 countries; *Bd* occurs in 53.5% (38 of 71) of the countries for which we have data; *Bd* is linked to mortalities in 18 of 38 countries having *Bd*; *Bd* occurs in 233 of 425 (55%) anuran species - in 17 of 25 families sampled, and; *Bd* occurs in 24 of 36 (67%) salamander species - in all 5 families sampled. Lists of "knowns, unknowns, and research priorities" were developed at the Tempe conference, including: 1) it is known that impact varies with species, strain, geography and life stage; 2) it is unknown how it spreads so quickly or why some animals are resistant; and 3) research is needed on prophylaxis, and environmental persistence. Break-out groups focused on topics including hygiene standards to reduce *Bd* spread, conservation plans for affected areas, fish hatchery and commercial supplier issues, and continuing the mapping effort. The Partners for Amphibian and Reptile Conservation (PARC) website (http://www.parcplace.org/Bd_conference.html) is serving as the portal for post-*Bd*-conference updates, and documents will be posted there such as conference abstracts, maps, break-out group notes, factsheets, disinfection protocols, and other management guidelines.

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Management for Controlling the Spread of Amphibian Diseases Through Trade

Amphibian diseases are spread through international trade in wildlife. Two amphibian pathogens of concern in the wildlife trade are the chytrid fungus *Batrachochytrium dendrobatidis* (Bd) and ranaviruses. These pathogens are associated with declines, die-offs, and even extinctions in wild and commercial populations of amphibians. Given the large numbers of animals moved through trade, and the high risk of spreading disease to new areas as a result of commerce, management action must focus on reducing the risk of disease spread through trade. The tiger salamander bait trade in the western U.S. is an example of one type of amphibian trade responsible for the movement of both Bd and ranaviruses. We present management suggestions for curbing the spread of amphibian disease through the bait trade in light of recent management changes aimed at limiting the spread of viral hemorrhagic septicemia (VHS), a viral pathogen of fish known to infect over 25 species throughout the Great Lakes region. Management tactics that reduce the spread of disease through commerce can reduce the risks associated with wildlife trade.

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Mountain Yellow-Legged Frog, *Rana muscosa*, Headstart and Breeding Program at the San Diego Zoo's Conservation and Research of Endangered Species (CRES) Department

Southern California's Mountain Yellow-Legged Frog *(Rana muscosa)* population has been eliminated from 99% of its historic range. Only 8 known populations of Mountain Yellow-Legged Frogs exist today in southern California's San Jacinto, San Gabriel, and San Bernardino mountains. The U.S. Fish and Wildlife Service has listed these 8 remaining populations as federally endangered and has recently designated critical habitat for the frogs in all three mountain ranges.

CRES received 80 tadpoles in August 2006 as part of an emergency salvage plan. The tadpoles were recovered from drying pools in the Dark Canyon area of the San Jacinto Mountains. As of December 2007 60 tadpoles have metamorphosed into frogs and the remaining tadpoles are developing very quickly. The two main goals of the program are to develop a successful Breeding Protocol for the Mountain Yellow-Legged Frog and to Headstart frogs for release into the wild.

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2007 Year in Review: Legal and Policy Developments Affecting Western Amphibians

Ms. Spooner will present on court decisions, Endangered Species Act developments, and other state and federal actions affecting rare and imperiled amphibian species, including the California red-legged frog, arroyo toad, and Scott Bar salamander.

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Amphibian Research in Northwest California: An Update on the Herpetology Research Group's Recent Activities

The Herpetology Group at Redwood Sciences Lab (USDA Forest Service, Pacific SW Research Station) with assistance from graduate students in the biology and wildlife departments at Humboldt State University has been studying the natural history, demography, and landscape ecology of amphibian assemblages in aquatic and terrestrial environments of Northern California for 23 years. A primary focus of our research has been to examine the relationships between amphibian biology and human land management practices. Amphibian populations in this region have declined due to detrimental forestry practices, introductions of non-native predators, and manipulations of the natural flow regimes of north coast rivers. We summarize recent studies showing how forest management has altered relict amphibian distributions in the Mattole, how the introduction of fish to high lakes has attracted new predators, how bullfrogs might be affecting native herpetofauna, and the importance of breeding sites to the foothill yellow-legged frog.

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An Assessment of Pulsed Flows on Foothill Yellow-legged Frog Habitat Hydraulics using Two-Dimensional Hydrodynamic Modeling

We used a freely available two-dimensional model, River2D, to evaluate changes in habitat suitability and availability for *Rana boylii* (Foothill yellow-legged frog) egg masses and tadpoles during pulsed flow events. Two study sites in Northern California, one on the unregulated South Fork Eel River and the other on the regulated North Fork Feather River, were selected for modeling. Simulated depths and velocities agreed well with measured field values. When coupled with a definition of breeding habitat suitability that encompassed the variability of field-measured values and the range of error within the model output, the model accurately predicted suitable breeding locations throughout the survey reach.

Using data on percentages of egg mass and tadpole loss associated with increased velocities, we assessed several scenarios of how pulsed flows affected habitat availability and suitability. In a seasonal (spring) pulse scenario, lower discharges provided the greatest weighted usable area for breeding, but higher initial discharges provided the greatest buffering capacity against lethal increases in velocity. In an aseasonal (summer) pulse scenario, only 20-30% of the suitable tadpole habitat in the unregulated site and <5% of the suitable habitat in the regulated site remained suitable during the pulse regardless of initial flow level. In both scenarios, the unregulated study site provided 2-3 times the buffering capacity of the regulated site. This was likely due to differences in channel morphology; the regulated site had an entrenched channel with steep banks, while the unregulated site had an asymmetric cross-sectional shape where shallow overbank areas provided refuge from high velocities as flows fluctuated.

This type of model-based methodology that can evaluate effects from flow fluctuation on individuals and local habitat conditions for multiple life stages would be useful for managing *R. boylii* or similar aquatic species in regulated river systems.

*Indicates speaker in multi-authored presentation.