

# California/Nevada Amphibian Populations Task Force

## 2015 Meeting



## ABSTRACTS

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### **Chytrid Infection, Drought, and Flow Regulation Create Multiple Stressors on Foothill Yellow-Legged Frog Populations in the Alameda Creek Watershed**

In the fall of 2013 we observed dead and dying juvenile foothill yellow-legged frogs (*Rana boylei*) in the Bay Area's Alameda Creek, a location where annual amphibian breeding censuses have been conducted since 2003. We attribute the die-off to an outbreak of chytridiomycosis, caused by the fungal pathogen *Batrachochytrium dendrobatidis* (Bd), in which recently metamorphosed frogs had the highest Bd loads among sampled individuals. Although hotspots for chytrid infection have been documented by others over the last decade many miles upstream of Calaveras Reservoir, these were the first indications of the effects of Bd infection among the lotic-breeding frogs downstream of the dam. In contrast to laboratory investigations of *R. boylei* from a North Coast California source population by others, these observations corroborate observations that *R. boylei* is susceptible to the lethal consequences of chytridiomycosis. The outbreak coincided with extremely low stream flows that concentrated frogs in drying pools and expanded the spatial distribution of non-native bullfrogs (*Lithobates catesbeianus*) in the stream network. Infection intensity and prevalence has varied through time with 2014 sampling indicating that infected bullfrogs may represent a reservoir for Bd when foothill yellow-legged frogs in the population are Bd negative. Over three years of drought, the number of *R. boylei* egg masses per stream kilometer (an index of adult female population size) upstream of the dams that regulate flow has decreased to the extent that abundance is no longer greater than in the regulated reaches where Bd and anthropogenic stressors occur.

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### **Rapid Evolution of *Rana draytonii* Behavioral Responses to an Introduced Predator**

The American Bullfrog (*Lithobates (Rana) catesbeianus*) is a voracious global invader implicated in the decline of native amphibian species, including the threatened California Red-legged Frog (*Rana draytonii*). Limited evidence suggests populations of native amphibians that have co-occurred with bullfrogs for many generations may show adaptive responses to bullfrog presence. We examined whether *R. draytonii* larvae from populations syntopic with bullfrogs would show a response to chemical cues from overwintered bullfrog larvae. In the presence of these cues, early-stage syntopic larvae decreased movement, consistent with an innate defense, while allotopic larvae did not show behavioral changes. Additionally, the syntopic larvae showed increased activity in the absence of cues, indicating a potential response to the competitive effects of coexisting with bullfrog larvae. These results indicate that rapid evolution can be induced in native amphibians by invasive bullfrogs. In ongoing work, we test if co-evolved red-legged frog larvae survive or grow better with bullfrogs than do allopatric populations.

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**Uncovering a Fossorial Species: Home Range and Habitat Preference of the Western Spadefoot, *Spea hammondi* (Anura: Pelobatidae), in Orange County Protected Areas**

Agricultural activity, urban development and habitat alteration have caused the disappearance of the western spadefoot (*Spea hammondi*) from 80% of its range in southern California. Despite the western spadefoot's continuing decline, little research has been conducted on its natural history. The home range of adult spadefoots is unknown, and their use of upland habitat is poorly understood. Both of these factors are important for the long-term conservation of the species because adult spadefoots spend the majority of their lives away from breeding pools. During the course of this study, radio transmitters were surgically implanted in 15 spadefoots and their movements and habitat use recorded for an average of 272 days. During that time, rain was the only significant predictor of spadefoot movement. The overall mean distance moved between burrow sites was 17.56 m (SD  $\pm$  23.96 m, N = 184). The mean distance moved away from the breeding pools was 40.04 m (SD  $\pm$  37.42, N = 200). The maximum distance moved away from the breeding pools was 261.99 m. The amount of clay was the only predictor of spadefoot burrow locations, with spadefoots burrowing in friable soil with significantly less clay than random non-spadefoot sites. This study enhances our understanding of a little-studied species and will assist land managers in the formation of effective management plans for the spadefoot.

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**Healing High Mountain Lakes: A Video about Aquatic Restoration in Sequoia and Kings Canyon National Parks (Video)**

Since 2001, Sequoia and Kings Canyon National Parks have been restoring high elevation aquatic ecosystems with a focus on recovering endangered mountain yellow-legged frogs. This video captures the essence of the project with crisp footage of scenery, wildlife, and habitat; staff interviews; and a storyline that seeks to educate interested parties on the history of the situation and recent, current and proposed work to address the situation. Bristlecone Media captured the footage in 2012 and 2013, conducted editing in 2013 and 2014, and produced the video in late 2014. The video will be available through links on the parks' website and Facebook page, and will be shown in the parks' visitor centers.

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**Status and Management of the Pacific Pond Turtle in San Diego County with Consideration of Road Effects**

The Pacific pond turtle has been severely impacted in coastal San Diego County with very few populations remaining and no detectable recruitment in recent years. While some healthy headwater populations remain, these can become subject to impacts from prolonged drought, predation from invasive species, and large scale wildfires. Careful management and restoration of coastal populations is necessary to insure the persistence of the species in the county. USGS has been working with partners to assess the status of Pacific pond turtle populations in San Diego County and to restore populations in coastal portions of the county. Assessments have identified and ranked stressors impacting the populations, including distance to nearest roads, size of nearest roads, presence of invasive species, and types of invasive species. We have found an association of road proximity, access, and size on the population health and demographics, finding no juvenile and fewer female turtles within the proximity of

larger, heavier access roads. We also have found an interaction between invasive species and the Pacific pond turtle where we have detected increased activity and recruitment after removal of nonnative aquatic species. Recent recovery efforts undertaken by USGS and its partners have yielded the only recent documented recruitment within San Diego's Multiple Habitat Planning Area and reestablished the species to the Otay River watershed from which it had been extirpated. As more lands have become conserved under the region's habitat conservation plans, restoration of the Pacific pond turtle can expand to other watersheds. However, continued management and restoration in the region need to take into consideration the effects of roads and potential for long term control of invasive species.

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### **Planning for Landscape Connectivity: Examples from Southern California**

The Southern California region is both a known ecological hotspot and an area with a large and increasing human population. To address species conservation and maintain habitat connectivity in this heavily populated region, numerous habitat conservation plans, natural community conservation plans, and regional plans have been developed that identify conservation areas and wildlife corridors. Due to their linear footprint and constraints from adjacent development, transportation corridors cross many conservation areas and wildlife corridors. Early coordination in the transportation project development process is crucial to the maintenance of wildlife connectivity in the Southern California region. Continuing coordination during and after project construction is necessary to ensure that wildlife crossing features are implemented correctly. We provide examples of efforts to maintain wildlife connectivity across transportation corridors through coordination from project development to project construction, and by thorough examination of conditions from each individual crossing to the greater extent of the transportation project limits, and finally, within the broader context of existing large-scale regional plans.

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### **Tracking Newts and Defensive Toxin Levels through Time in the Santa Monica Mountains**

Behaviors that influence habitat selection strongly determine species movement patterns. One component of animal behavior that largely influences movement patterns and habitat choice is site fidelity. Newts demonstrate remarkable site fidelity, homing to the same region and even remaining in the same pool during a breeding season. However, some males have been observed to abandon a breeding pool. In this study, we utilize mark-recapture data from a subset of a population of California newts (*Taricha torosa*) to track male individual's movement patterns within a single stream over four breeding seasons. During this time, dermal tissue samples were also collected to measure individual's concentrations of the chemical defense compound tetrodotoxin (TTX). We evaluated whether relative TTX concentrations and temporal or morphological variables could explain fidelity to a site. Tree and random forest models show that relative TTX concentrations best explain fidelity to a breeding pool. These results suggest that TTX may facilitate competitive or breeding interactions. Surprisingly, TTX concentrations of individuals and group means fluctuated over the four years of sampling, indicating that TTX is not a static trait, and thereby may not be a phenotype in lockstep with predator resistance.

**CLEVENGER, ANTHONY P.** Western Transport Institute, Montana State University, Bozeman, MT.

### **Road Ecology: Science-based Solutions for the Big and Small**

Roads are a primary contributor to habitat destruction and fragmentation, yet have only recently become a major focus of conservation efforts. Road ecology originated from the realization that sprawling road systems can have substantial effects on species and ecosystems. Understanding these effects and developing science-based solutions to mitigate them will be central to large-scale landscape connectivity efforts. North American transportation agencies have been slow to adopt ecosystem and landscape-based approaches to planning. Large-landscape connectivity efforts focus on mitigating habitat fragmentation and increasing ecological connectivity at the landscape scale; however, local scale mitigation is equally important for large and small fauna. Wildlife crossing structures and engineered fauna passages are an increasingly popular strategy for restoring connectivity across highways, but are only as effective as the management strategies developed around them. Coordination is needed between land management and transportation agencies for local scale mitigation to be of value to landscape scale conservation planning.

**DAGIT, ROSI.** Resource Conservation District of the Santa Monica Mountains, Agoura Hills, CA, rdagit@rcdsmm.org.

### **Drought Impacts and Status of an Isolated Population of Western Pond Turtles (*Actinemys marmorata*) in the Santa Monica Mountains**

Drought impacts to western pond turtles (*Actinemys marmorata*) are thought to pose a threat by reducing habitat and available food, but few studies have documented this effect. A 12 year mark-recapture study of an isolated population of *A. marmorata* in the Santa Monica Mountains provides data on habitat availability, recruitment, growth patterns and mortality associated with varied rainfall conditions, ranging from drought to above average wet years. Over 300 individuals were tagged, with 190 individuals captured more than once. Reproduction and recruitment were limited during dry years, but increased following wet years when increased pond habitat was available. Mortalities were also higher following dry years, with the highest recorded loss in fall 2014, following a three-year drought. The status and trends of this population, the largest remaining in the Santa Monica Mountains, has regional significance and provides important information needed to avoid local extirpation of this species.

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### **Re-introduction of the Federally Threatened California Red-legged Frog (*Rana draytonii*) to the Santa Monica Mountains**

Historical data suggests that federally Threatened California red-legged frogs (*Rana draytonii*) were in all of the major streams of Santa Monica Mountains National Recreation Area (SAMO). Currently, there is only one population of about 100 adult California red-legged frogs near the park, in the Upper Las Virgenes Canyon Open Space Preserve (ULV). USFWS adopted a species recovery plan in 2002 which defined actions needed to recover the species to sufficient numbers throughout all or part of their range, with the eventual goal of de-listing. The ULV population is genetically unique and distinct from other populations in Ventura and Los Angeles Counties, therefore it will be important to populate streams with local individuals. In 2011, we initiated a project to re-introduce California red-legged frogs into suitable stream habitats in SAMO. In this talk, we will provide information about project development, results of

the 2014 translocations, and future plans. Our goal is to establish new populations of California red-legged frogs in the Santa Monica Mountains, both to increase the overall population size and to create redundant populations which would prevent the extirpation of the species from the area if a catastrophic event occurred in ULV.

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### ***Rana boylei* Aging: A Growing Concern**

We analyzed length data from 3,379 captures of 1,640 individual frogs surveyed during 2004 to 2013 from a coastal population and a Sierran foothill population of *Rana boylei* to determine growth rates and longevity. Growth analysis using the von Bertalanffy growth equation indicates that the Sierran population grows faster than the coastal population, and that female frogs grow faster than male frogs and achieve a larger asymptotic size. Maximum estimated age was 13 years for both males and females surveyed in the Sierran population and 12 and 11 in the coastal population, respectively. Length frequency histograms by year indicate that recruitment varied between sites and that one site may have had no recruitment since surveys began in 2004. The relatively long life span of this imperiled frog bodes well for its ability to recover from short term perturbations that limit recruitment.

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### **The Value of Museum Collections: The Examination of Museum Specimens Leads to a Contraction of the Known Geographical Extent of the Endangered Arroyo Toad (*Anaxyrus californicus*)**

The recovery strategy for an endangered species requires accurate knowledge of its distribution and geographic range. Although the best available information is used when developing a recovery plan, uncertainty often remains in regard to a species actual geographic extent. The arroyo toad (*Anaxyrus californicus*) occurs almost exclusively in coastal drainages, from Monterey County, California, south into northwestern Baja California, Mexico. Through field reconnaissance and the study of preserved museum specimens we determined that the four reported populations of the arroyo toad from the Sonoran Desert region of Riverside, San Diego, and Imperial counties, California are in error. Two additional sites in the Sonoran Desert are discussed regarding the possibility that the arroyo toad occurs there. We recommend the continued scrutiny of arroyo toad records to maintain a high level of accuracy of its distribution and geographic extent.

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### **Challenges and Opportunities: Evaluating the Conservation Status of Amphibians in California**

Many amphibian populations are in decline worldwide. Accurate assessment of species vulnerability is necessary in order to make informed management decisions. Challenges when evaluating the conservation status of amphibian species include lack of data, lack of infrastructure for sharing data, and lack of funding to gather data. A recent evaluation of 38 species of amphibians in California revealed a general lack of data on abundance and life history making rigorous evaluation of demographic trends

impossible. There is also a lack of access to existing field survey data. This results from the lack of a data repository or systematic filing system. In the best circumstance data and reports can be obtained by contacting an author directly. Lastly the evaluation revealed spatial data errors in georeferenced museum data. These errors appear to result primarily from automated georeferencing software and human error when entries are transcribed. Solutions for these challenges are available. Commitment from government agencies and NGOs to fund field surveys and life history research would help fill data gaps. Cloud services can allow for an online repository of published and unpublished data on amphibian distribution and abundance. Correcting spatial data errors is possible but will take considerable effort as current automated methods appear inadequate to address the issue.

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### **Re-Frogging America: Building Wetlands for Wildlife**

Habitat destruction is the number one cause of amphibian population declines worldwide and the majority of America's wetlands have been destroyed or modified. To remedy this problem, SAVE THE FROGS! is Re-Frogging America by constructing actual wetlands for frogs and other wildlife. Constructing wetlands is a fantastic method of educating students, teachers and community members about amphibians and ensuring that amphibians have a home in which to live and breed. In May 2014, SAVE THE FROGS! designed 15 wetlands around California. In October 2014 we broke ground with our first wetlands and we plan another week of wetland construction March 22-28th, 2015. We hope you can join us at a Wetland Construction Workshop and get your organization involved in Re-Frogging America! Scientists can assist by developing monitoring protocols for new wetlands, encouraging undergraduates to assist and partnering on grant opportunities.

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### **Implications of the Drought on California Tiger Salamanders and the Downstream Consequences on their Prey Amphibian Species (poster)**

The effects caused by the interaction of different anthropogenic disturbances are a major concern in the field of conservation biology. The native California Tiger Salamander (*Ambystoma californiense*) and invasive Barred Tiger Salamander (*Ambystoma mavortium*) hybridization system has been significantly impacted by habitat alteration and climate change, and is an excellent example to study this interplay of anthropogenic disturbances. In this study, we analyze how the 2014 drought in California impacted the California Tiger Salamanders (CTS) of three different genetic compositions: fully hybridized, superinvasive genes only, and pure CTS. We found that the drought more severely affected the superinvasives, whereas the hybrid population had a reproductive advantage. We also showed that perennial ponds can better facilitate *Ambystoma* breeding than vernal ponds in time of drought. The interactions of *Ambystoma* and its prey amphibian species were also investigated to evaluate the downstream effects of the drought. We showed that the presence and density of *Ambystoma*'s prey amphibian species, specifically *Pseudacris regilla*, are negatively impacted by the presence of *Ambystoma*. These findings provide evidence of the complex interactions of different anthropogenic disturbances and their resulting effects on the ecosystem, giving significant implications for future conservation management issues.

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**Life in the Fast Lane: Urban Lizards Ignore the Risks (poster)**

Populations express inherited traits and learned behaviors molded by the local environment. The study of a single population cannot be assumed to represent the breadth of behavior for a species as a whole. For populations of amphibians and reptiles in urban areas, local adaptations include responses to the activities of humans. Although the majority of people do not specifically target amphibians and reptiles for capture, human activity does result in the incidental deaths of small animals; thus, humans could be seen to occupy the role of predator. Flight initiation distance is the distance to which a predator is permitted to approach before the prey initiates flight behavior. We measured flight initiation distances in two populations of Western fence lizards (*Sceloporus occidentalis*), one in a rural and one in an urban environment. Lizards at the rural site initiated flight at significantly longer distances than those at the urban site. These results support the prediction that lizard behavior can be influenced by differences in human exposure and predator recognition in their environments. Lizards develop tolerance to humans in urban areas in order to maximize fitness by reserving energy and utilizing resources for longer periods of time. The findings from this study demonstrate that researchers should be aware of differences in human exposure between populations of study animals and should choose sites appropriate to the investigation. This study also supports the notion that populations living in close association with humans may ignore risks posed by non-predatory activities that are, nonetheless, lethal to wildlife.

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**Amphibian Mortality on Roads: A Case Study in Santa Cruz Long-toed Salamander Habitat**

Vehicular traffic is responsible for the death of an estimated 1 million animals in the United States daily. Biologists are concerned that road mortality may be a significant factor threatening the Santa Cruz long-toed salamander (*Ambystoma macrodactylum croceum*), a critically-endangered endemic amphibian found only in a very localized area of California. However, no studies have quantified the impact of road mortality on this species. To study this question, we collected data on roads in Santa Cruz County, California, during two *A. m. croceum* winter migratory seasons from 2011-2013. We surveyed for animals and the number of cars along three road transects that separated breeding ponds from upland habitat; two transects were adjacent to known *A. m. croceum* breeding ponds and one was adjacent to a potential breeding pond. We estimated the likely number of animals killed on these roads and the role traffic levels played in mortality. During the course of the study, we found five different amphibian species in the *A. m. croceum* habitat. Of the 11 *A. m. croceum* found on the road transects, 64% were dead. Based on the length of the breeding season and other factors, I estimated 134 *A. m. croceum* were killed during migratory seasons 2011-2013. Analysis of vehicles/hour indicated that between 51% and 67% of cars traveling the roads adjacent to *A. m. croceum* habitat were not residents of the area, but were traveling the roads to avoid the near-by highway. Thus, at least 50% of travelers did not need to be on these roads with the potential to kill an endangered species. Based on these findings, I recommend that the California transportation and wildlife agencies work together to limit traffic in this sensitive area to residents only. In addition, educational signs and under-road systems to assist animal movement within migration corridors could also reduce mortality.

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### **Populations of the Endangered Frog *Rana sierrae* are Increasing in Abundance Despite Ongoing Disease**

The Sierra Nevada yellow-legged frog, *Rana sierrae*, was once the most abundant amphibian in California's Sierra Nevada mountains. Due primarily to the introduction of non-native trout into naturally-fishless habitats and the spread of the amphibian chytrid fungus, *R. sierrae* has disappeared from more than 90% of its original range. As a result, in 2014 it was listed as "endangered" under the U.S. Endangered Species Act. Nearly all remaining populations are infected with the amphibian chytrid fungus, and large-scale population trends remain poorly described. We used results from more than 8,000 surveys conducted in Yosemite National Park during the period 1992-2012 to quantify trends in *R. sierrae* abundance. These surveys were conducted at nearly all of Yosemite's approximately 450 *R. sierrae* populations. Analysis of these time-series using Bayesian hierarchical models indicated that on average populations are growing at approximately 14% per year. These results provide the first indication of large-scale increases in *R. sierrae* abundance, a remarkable result given the ongoing impacts of the amphibian chytrid fungus. They also highlight the importance of protecting even small *R. sierrae* populations because of their potential to recover.

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### **Developing Wildlife Road Crossing Structures for Herpetofauna**

Road impact mitigation measures have been taken for reptiles and amphibians over the last 50 years, starting in central Europe and with greatest uptake since the 1990s. There are now several thousand systems in Europe and several dozen in North America, many of which are in California. Since the 2008 National Cooperative Highway Research Program report, *Evaluation of the Use and Effectiveness of Wildlife Crossings*, more projects are being developed in North America. Species-based mitigation and compensation measures relating to roads, arising from protected species legislation, may differ to a whole-ecosystem approach and the tension between the approaches is one of several concerns. The need to determine success criteria, including "how many animals need to cross," is a current focus of attention and this may relate to habitat quality and persistence (including long term management) on either side of a road. There is need to categorize system design objectives and to standardize good quality, long lasting construction materials that may be subject to both the harsh climatic and hard-use road side environment. We must also check that what is built works well enough to be cost-effective and to look out for unforeseen problems in any State-wide roll out of crossing constructions. Fortunately, camera and software technology is advancing to a point where monitoring of dispersing animals can now avoid trapping them – a major obstacle to previous behavioral studies. Still and video night vision cameras allow precision in detecting animals moving through crossings and for the first time will allow us insight into how purpose-built structures perform for different species

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### **Influence of Landscape Heterogeneity on Genomic Diversity and Adaptation in the Yosemite Toad (*Anaxyrus canorus*)**

Amphibian conservation in the 21st century is beset by many anthropogenic impacts including habitat alteration, chemical toxicants, pandemic disease, and climate shifts. The Yosemite Toad (*Anaxyrus canorus*) is a species of alpine amphibian endemic to the high-elevation and federally protected Sierra Nevada of California, yet up to 69% of its populations have recently been extirpated. Although limited evidence exists for species-wide declines due to pesticide use or disease, climate change is projected to have a major hydrological impact on its core meadow habitat. Further, little is known about the relative importance of local habitat stability for larval toads compared to adult dispersal corridors in promoting population persistence. In this study we use double-digest RADseq to produce 1000s of unlinked nuclear SNPs along with numerous remotely-sensed and locally collected habitat attributes in a landscape genomics framework to answer three primary questions: (1) Which environmental, topographic, and climatic attributes most facilitate gene flow? (2) How do node-based (meadow) versus link-based (landscape) habitat attributes contribute to genetic connectivity among toad populations? (3) Is there evidence that toads are locally adapted, or exhibit a pattern of isolation by adaptation (IBA)? We use gravity modeling and multivariate graph-theoretical approaches that have wide application to modeling microevolutionary dynamics in natural populations of amphibians. Our preliminary results show a scale-dependent effect of climate change on gene flow, and putative adaptation at markers with very interesting functions. Discovering the interplay between migration and adaptation to a changing environment are crucial first steps toward properly mitigating further declines, and our results will have significant utility for prioritizing the future management and conservation of this iconic California native.

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### **Statewide Coordination and Stakeholder Input to Inform 2015 CDFW Regulation Changes Affecting Scientific Collecting Permits (poster)**

California Department of Fish and Wildlife (CDFW) authorizes take of species via Scientific Collecting Permits (SCPs) for bona fide scientific, educational and propagation purposes. CDFW issues approximately 1,200-1,500 permits annually for these purposes, while evaluating direct and cumulative impacts of take on marine and inland fish and wildlife populations. Research reports and publications facilitated by SCPs help inform land use planning, conservation and management throughout California. In response to the 2012 enactment of Assembly Bill 2402 updating Fish and Game Code sections 1002 and 1002.5, CDFW is revising Title 14, Section 650 of the California Code of Regulations. The Departmental rulemaking process will involve stakeholder outreach in early 2015 to help inform regulatory revisions aimed at clarifying legal uses of SCPs, entity vs. individual SCPs, and the relationship to Memoranda of Understanding for state-listed, candidate, and fully protected species. Based on previous input from SCP holders, we highlight plans for statewide coordination and improvement in timely processing and issuance of SCPs, including a web-based application, reporting and data management system. CDFW's vision for SCPs is that internal and regulatory improvements will

continue to support stakeholders and encourage research, conservation and education, while protecting California's wildlife.

**MCCARTNEY-MELSTAD, EVAN<sup>1\*</sup>, BENJAMIN FITZPATRICK<sup>2</sup>, JARRETT R. JOHNSON<sup>3</sup>, GENEVIEVE MOUNT<sup>1,4</sup>, H. BRADLEY SHAFFER<sup>1</sup>.** <sup>1</sup>Department of Ecology and Evolutionary Biology, University of California, Los Angeles, Los Angeles, CA, evanmelstad@ucla.edu; <sup>2</sup>Department of Ecology and Evolutionary Biology, University of Tennessee, Knoxville, TN; <sup>3</sup>Department of Biology, Western Kentucky University, Bowling Green, KY; <sup>4</sup>Department of Biological Sciences and Museum of Natural Science, Louisiana State University, Baton Rouge, LA.

### **Conservation Genomics of the California Tiger Salamander (*Ambystoma californiense*): Past, Present, and Future**

The California Tiger Salamander (*Ambystoma californiense*, CTS) is a federally-protected species that has been subject to hybridization with the invasive barred tiger salamander (*Ambystoma tigrinum*) since the latter's introduction in the Salinas Valley 60 years ago. Prior genetic work has shown that some non-native alleles are spreading through the landscape much faster than others, suggesting that these genes are under strong selection and that traditional sources of genetic data may not be capturing the full extent of introgression. While we may wish to manage highly-introgressed areas differently than pure-CTS areas, we do not have a full understanding of the genome-wide level of mixing across the landscape or clear expectations for how hybridization will proceed in the future. Sequencing the genomes of many salamanders across the landscape over many generations would allow us to understand the full extent of introgression, but their extremely large genomes (over 30 gigabases) make this untenable. We are instead sequencing thousands of exons from thousands of genes to get a genome-wide perspective without sequencing massive amounts of unusable, repetitive DNA, and I will show how we have implemented and optimized this exon-capture technology in the laboratory. Finally, I will discuss how we will use the DNA sequence data from temporally-spaced tissue samples to characterize how the wave of hybridization has progressed over the last 30 years, determine the present state of introgression in CTS populations across California, and predict which populations are good candidates for management interventions to prevent future hybridization.

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### **Using Genomic Tools for the Conservation of the Western Spadefoot Toad, *Spea hammondi* (poster)**

The western spadefoot toad, *Spea hammondi*, is a vernal pool amphibian found in grassland and scrub habitat in Southern California and the Central Valley. As these areas have undergone extensive agricultural and residential development, the spadefoot has been extirpated from 30% of its range in the Central Valley and a staggering 80% in Southern California. The extent of this habitat loss has earned *S. hammondi* a place on the California list of Species of Special Concern. Despite this listing, there is a dearth of ecological, behavioral, and genetic studies on *S. hammondi*; accordingly, we know little of how western spadefoots and their genes interact and change with the landscape. To better assess the viability of the western spadefoot going into the future, we are developing a set of genomic tools to analyze genetic variation and connectivity of spadefoots among vernal pools throughout the 35,000-acre Nature Reserve of Orange County. By sequencing thousands of loci across the spadefoot genome, we can precisely measure genetic diversity, analyze genetic connectivity among vernal pools and regions, and quantify resistance of physical landscape features to gene flow. Future studies will broaden this sampling

across California to determine genetic connectivity and structure at multiple spatial scales. Results will aid in the development of appropriate conservation measures for the persistence of the western spadefoot in California.

**PATTERSON, LAURA C.** California Department of Fish and Wildlife, Sacramento, CA, [laura.patterson@wildlife.ca.gov](mailto:laura.patterson@wildlife.ca.gov).

### **California Department of Fish and Wildlife's Sensitive Amphibian and Western Pond Turtle Research and Conservation Efforts**

This talk will discuss some of the on-going and future efforts California Department of Fish and Wildlife staff are undertaking to study and conserve sensitive amphibians and the western pond turtle. Topics include habitat restoration, population monitoring, reintroduction, rescue, and enforcement.

**PAULY, GREGORY B.\***. Section of Herpetology, Natural History Museum of Los Angeles County, Los Angeles, CA, [gpauly@nhm.org](mailto:gpauly@nhm.org).

### **Studying Urban Amphibian Populations through Citizen Science**

The biota of Southern California is changing rapidly. In the past century, the human population within this region has grown dramatically, causing habitat loss and fragmentation. The resulting range shifts and declines of native species have been accompanied and exacerbated by introductions of nonnative species. Unfortunately, researchers' ability to study the rapidly changing distributions of native and nonnative species is limited because of declines in natural history research and funding. The standard method for assessing biodiversity is to tally occurrence records from museum databases. However, fewer and fewer specimens are being deposited in natural history collections; thus, biodiversity assessments that rely on recent records (e.g., tracking responses to urbanization) are data limited. Records are even rarer for urbanized areas because much of the land is private property that biologists cannot easily survey. Citizen science can help fill this gap in our biodiversity knowledge. Citizen science crowdsources data collection by asking the public to photograph organisms they encounter and submit those photos to online databases. I have implemented this approach through the Reptiles and Amphibians of Southern California (RASCals) citizen science project ([www.inaturalist.org/projects/RASCals](http://www.inaturalist.org/projects/RASCals)). Citizen science has dramatically increased the number of reptile and amphibian occurrence records for southern California, and it has also resulted in important discoveries, many of which have been published with citizen scientist coauthors. Recent amphibian discoveries through citizen science include the first records of Coqui Frogs established in Los Angeles County.

**PERALTA GARCIA, ANNY<sup>1\*</sup>, JONATHAN Q. RICHMOND<sup>2</sup>, BRADFORD D. HOLLINGSWORTH<sup>3</sup>, PATRICIA GALINA-TESSARO<sup>1</sup>, AND ROBERT N. FISHER<sup>2</sup>.** <sup>1</sup>Centro de Investigaciones Biológicas del Noroeste, S. C. La Paz, Baja California Sur, Mexico, [aperalta@cibnor.mx](mailto:aperalta@cibnor.mx); <sup>2</sup>USGS Western Ecological Research Center, San Diego, CA; <sup>3</sup>San Diego Natural History Museum, Herpetology Department, San Diego, CA.

### **Population Threats and Declines of the California Red-Legged Frog (*Rana draytonii*) in Baja California, Mexico**

We assess the distribution and threats to *Rana draytonii* populations in Baja California, México. We searched locality records in online databases, museum collections and published literature, and conducted surveys at 41 sites during 2013-2014. We documented 22 unique historical locality records from 1889 to 2006, with the Sierra San Pedro Mártir accounting for 90% of the records. We observed *R. draytonii* at

ten locations in three watersheds (San Rafael, San Telmo and Santo Domingo). Our detection of no frogs at 21 sites between the Sierra San Pedro Mártir and the US–Mexican border suggest populations in that area may be extirpated. Frog captures ranged from one to nine frogs per site visit, except for La Grulla, where we captured 137 frogs during two site visits. In the San Pedro Mártir, we did not detect frogs at seven historical localities, including the highest elevation record at La Encantada. Threats across our study area include water reclamation for agriculture, introduction of non-native species, and cattle ranching. The species seems to be extirpated from approximately 12 the historical sites in Baja California. Management of the remaining populations is urgently needed to prevent further declines. Extant populations in this region appear to be separated from the next group north (Santa Monica Mountains, southern California, USA) by approximately 500 km. Further research is needed to assess the genetic connectivity of remnant populations.

**PIOVIA-SCOTT, JONAH<sup>1\*</sup>, KAREN POPE<sup>2</sup>, JANET FOLEY<sup>3</sup>, SHARON LAWLER<sup>4</sup>, BENNETT HARDY<sup>5</sup>, and MONTY LARSON<sup>6</sup>.** <sup>1</sup>Department of Biology, University of California, Riverside, CA, jonahps@ucr.edu; <sup>2</sup>Pacific Southwest Research Station, United States Forest Service, Arcata, CA; <sup>3</sup>Department of Veterinary Medicine and Epidemiology, University of California, Davis, CA; <sup>4</sup>Department of Entomology, University of California, Davis, CA; <sup>5</sup>San Bernardino, CA; <sup>6</sup>Arcata, CA.

#### **What Drives Variation in the Effect of a Fungal Pathogen on the Cascades Frog (*Rana cascadae*)?**

The fungal pathogen *Batrachochytrium dendrobatidis* (Bd) has had devastating effects on amphibians worldwide. However, there is often significant variation in this pathogen's effect on susceptible hosts, such as the Cascades frog (*Rana cascadae*). This is particularly apparent in northern California, where *R. cascadae* has experienced severe declines in the southern Cascade Mountains, but is still common in the Klamath Mountains. We present evidence from field studies and laboratory experiments suggesting that variation in the effect of Bd on *R. cascadae* is associated with environmental conditions (such as temperature), between-strain differences in pathogen virulence, and host life stage. We also show that treatment with anti-fungal drugs can enhance the survivorship of vulnerable life stages in the field.

**RICHMOND, JONATHAN Q.<sup>1\*</sup>, ANNY PERALTA-GARCIA<sup>2</sup>, ADAM R. BACKLIN<sup>1</sup>, ELIZABETH GALLEGOS<sup>1</sup>, and ROBERT N. FISHER<sup>1</sup>.** <sup>1</sup>US Geological Survey, San Diego, CA, jrichmond@usgs.gov; <sup>2</sup>Centro de Investigaciones Biológicas del Noroeste, La Paz, Baja California Sur, México.

#### **Ugly at the Edges: Genetic Consequences of Rapid Population Declines and Local Extirpation within the Distribution of the California Red-Legged Frog *Rana draytonii***

Local extirpation and population declines have led to the formation of large gaps within the distribution of the California red-legged frog *Rana draytonii*. These gaps have had dramatic effects on the landscape genetics of the species, particularly at the edges of the distribution where populations are most vulnerable to extinction. In this talk, we will summarize the findings of our most recent work on the species, much of which has focused on identifying center-edge trends in genetic diversity, genetic differentiation, and landscape genetic structuring, and inferring what these patterns reveal about the causes of range edge decay. We will also discuss our ongoing efforts to evaluate the conservation status of the last remaining populations of *R. draytonii* in the Sierra San Pedro Martir of Baja California, and provide an update on our progress towards characterizing the rangewide evolutionary history of the species using next-generation DNA sequencing. Our current data challenge some longstanding perceptions about the historical biogeography of the species and raise important questions about where management efforts should be focused.

**SHAFFER, H. BRADLEY<sup>1\*</sup>, and CHRISTOPHER SEARCY<sup>2</sup>.** <sup>1</sup>Department of Ecology and Evolutionary Biology, University of California, Los Angeles, Los Angeles, CA, brad.shaffer@ucla.edu; <sup>2</sup>Department of Biology, University of Toronto, Mississauga, ON, Canada.

### **Landscape Ecology of the California Tiger Salamander (*Ambystoma californiense*): Past, Present, and Future**

We understand amazingly little about the terrestrial ecology of most pond or stream-breeding amphibians, making their conservation and management often little more than a series of educated guesses. For 20 years we have run a complex of drift fence arrays in Monterey and Solano County to quantify the terrestrial habitat requirements of the California Tiger Salamander (*Ambystoma californiense*, CTS), a federally-protected species that has lost the bulk of its valley vernal pool habitat over the last 150 years. Our field data indicate that the CTS routinely uses habitat two kilometers distant from a breeding site and requires hundreds to thousands of acres of upland habitat to support a single breeding pool. In support of these results, we identified individual metamorphs that moved 1000 m or more in a few nights, demonstrating the overland migratory abilities of the species. In a related line of investigation, we compiled all known CTS localities, built Maxent ecological niche models for the species, and projected those models into the most likely future California climate scenario for the year 2070. The results suggest that the regions most likely to have the environmental attributes that will continue to support the species are geographically restricted and currently occupied by hybrid, rather than pure CTS. Our results highlight the challenges involved with ecologically characterizing cryptic, biphasic amphibians, the need for long-term field studies, and the power of niche models in managing under a rapidly changing climate.

**SIGAFUS, BRENT H. <sup>1\*</sup>, BLAKE R. HOSSACK<sup>2</sup>, ERIN L. MUTHS<sup>3</sup>, CHRISTOPHER J. JARCHOW<sup>1</sup>, RICHARD B. CHANDLER<sup>4</sup>, and CECIL R. SCHWALBE<sup>1</sup>.** <sup>1</sup>U.S. Geological Survey, Sonoran Desert Research Station, University of Arizona, Tucson, AZ, bsigafus@usgs.gov; <sup>2</sup>U.S. Geological Survey, Northern Rocky Mountain Science Center, Missoula, MT; <sup>3</sup>U.S. Geological Survey, Fort Collins Science Center, Fort Collins, CO; <sup>4</sup>Warnell School of Forestry and Natural Resources, University of Georgia, Athens, GA.

### **Modelling Colonization of a Reintroduced Population of Chiricahua Leopard Frogs**

Managing a species with an intensive tool like reintroduction may focus on single sites or entire landscapes. For vagile species like the federally-threatened Chiricahua leopard frog (*Lithobates chiricahuensis* [CLF]), both suitable colonization sites and suitable dispersal corridors between sites are needed. Following the eradication of the invasive American bullfrog (*Lithobates catesbeianus*) from most of Buenos Aires National Wildlife Refuge (Altar Valley, AZ), captive CLF tadpoles were reintroduced into three stocks ponds (cattle tanks) on the refuge. Populations became established at all three reintroduction sites, followed by colonization of neighboring ponds in subsequent years. Based on this initial post-reintroduction colonization of neighboring ponds, we developed a habitat connectivity model to identify potential dispersal corridors. Next, using data on pond occupancy between 2007 and 2012, habitat characteristics, and pond isolation, we modeled predicted colonization of ponds through the valley as well as the long-term extinction risk for the metapopulation. Collectively, these efforts should provide insight into the security of CLF in the Altar Valley and help inform other reintroduction efforts.

**WESTPHAL, MICHAEL F.<sup>1\*</sup>, RICHARD B. SEYMOUR<sup>2</sup>, DIANE KODAMA<sup>3</sup>, and H. BRADLEY SHAFFER<sup>4</sup>.** <sup>1</sup>U.S. Bureau of Land Management, Hollister Field Office, Hollister, CA, mwestpha@blm.gov; <sup>2</sup>Seymour & Associates, Sierra Madre, CA; <sup>3</sup>U.S. Fish and Wildlife Service, Don Edwards NWR, Newark, CA; <sup>4</sup>Dept. of Ecology and Evolutionary Biology, UC Los Angeles, Los Angeles, CA.

**Highway One Revisited: Twenty Years of Road Surveys for California Red-legged Frogs in Coastal Santa Cruz and San Mateo Counties**

In 1994-1995 we collected over 300 road-killed California red-legged frogs, *Rana draytonii*, from an 80 km reach of Highway One, a coastal road that transects across numerous watershed outlets between the city of Santa Cruz and Half Moon Bay. We revisited the study site in 2010-2013, using the same methods. We collected over 100 additional samples, and found red-legged frogs to be represented in nearly every major locality in both time periods, with similar distribution and abundance. California red-legged frogs appear to be sustaining a strong metapopulation on the coastal side of the San Francisco Peninsula. In the near future we will be conducting genetic analysis of both tissue sets to assess population dynamics over a twenty-year period in the region.

\* Indicates speaker in multi-authored presentation