California/Nevada Amphibian Populations Task Force 2020 Meeting

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ABSTRACTS

California Red-legged Frog from La Grulla, Sierra San Pedro Mártir, Baja California, Mexico (photographed by Bradford Hollingsworth).

ORAL PRESENTATIONS

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To Treat or Not to Treat: Disease Considerations for a California Red-legged Frog Conservation Introduction

Disease risk is one of many important factors to evaluate prior to reintroductions and translocations. *Ex-situ* inoculations may improve post-release disease outcomes in susceptible species. California red-legged frogs (*Rana draytonii*) are generally considered tolerant of infection with the fungal pathogen *Batrachochytrium dendrobatidis* (*Bd*; the causative agent of chytridiomycosis) because they appear to persist in populations where *Bd* is present; however, chytridiomycosis mortality and high pathogen burdens have been observed in this species. Our objectives in this study were to test the *Bd* susceptibility of *R. draytonii* and to measure the species' ability to mount an adaptive immune response. If *R. draytonii* is *Bd* susceptible and inoculation treatments improve disease outcomes post-release, this may be a viable and necessary treatment for translocated individuals. We experimentally inoculated the species with four distinct *Bd* isolates known to be highly pathogenic to a Sierra Nevada congener, *Rana muscosa*. We present the results of this *ex-situ* inoculation study, as well as preliminary findings of the *Bd* status of study animals after infection clearing and subsequent release to the wild.

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The Long and Winding Road Toward Recovering Endangered Mountain Yellow-legged Frogs in the Southern Sierra Nevada

Sequoia and Kings Canyon National Parks (SEKI) protect both species of endangered mountain yellow-legged frogs (*Rana muscosa* and *R. sierrae*). The parkwide population, however, is vulnerable to being extirpated, primarily due to nonnative trout and amphibian chytrid fungus (*Bd*). While eradicating trout populations to restore critical habitat is relatively straightforward, it can be challenging due to the size and complexity of lake basins and the strong migration ability of common taxa (*Oncorhynchus mykiss* spp.). Additionally, nearly all of the extant frog populations are still naïve to *Bd* or struggling to develop enough disease resistance to become 'persistent.' For approximately 20 years collaborative teams have endeavored to restore lake ecosystems and recover mountain yellow-legged frogs in and near SEKI using research, applied and adaptive management, and an evolving suite of methods. This presentation describes actions conducted in 2018-2019 by staff from SEKI, UCSB, Oakland and San Francisco Zoos, USGS, and CDFW. Although results show both progress and continuing challenges, recent developments point toward incremental positive change at the landscape scale.

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A New Road Crossing Structure for Small Animals: Case Study with the Yosemite Toad

Many small animals, especially amphibians that must migrate between aquatic and terrestrial habitats, are susceptible to negative impacts from roads within their habitat. Yosemite toads have been tracked moving away from breeding meadows over 0.78 miles through dry upland habitats where they spend most of their lives. Toads move during the day or night, especially during summer rain events making them susceptible to mortality. Over a 4-month period in the summer of 2017, Sierra National Forest staff recorded 88 federally threatened Yosemite toad (*Anaxyrus canorus*) mortalities spanning about 2 miles along a single forest service road (9S09) that crossed through occupied terrestrial habitat. Narrow tunnels (<1m) under roads with directional barriers are a standard mitigation solution to reduce amphibian road mortality along roadways. However, there is recent evidence that these tunnel mitigation systems may act to filter migratory movements of species that disperse over large areas and unintentionally cause population decline. For these situations, larger movement corridors across roads may be warranted. In 2018 we tested a new and novel passage prototype, an 8" high elevated road segment using road mats designed for use by heavy equipment at construction sites. The prototype was installed on top of the road along a 9S09 Yosemite toad mortality "hotspot" providing a safe crossing nearly 100' wide while allowing both light and rain to pass through. We monitored toad activity along attached directional fencing and under the passage using specialized cameras and conducted regular road mortality surveys. In 2018, we recorded many toads using the passage and no mortality within the project footprint. This concept is currently being adapted to improved roads and highways and can be made to any length to improve connectivity of sensitive small animals in roaded areas. This study supports a broader research program to inform best management practices for barrier and crossing systems for sensitive amphibians and reptiles in California.

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Evaluating Reintroductions of Sierra Nevada Yellow-legged Frogs (*Rana sierrae*) to Streams

We evaluated reintroductions as a recovery tool for the federally endangered Sierra Nevada yellow-legged frog (*Rana sierrae*) in streams. We studied demography, habitat relationships, and movement ecology from 2016–2018 in four diverse streams. We compared data for wild and captive-reared frogs in one stream to test a population augmentation. We quantified demography with mark-recapture data, habitat relationships at the scales of geomorphic unit (pools, riffles,

runs) and microhabitat (immediate proximity of frogs), and movements with marked and radio-tracked frogs. Populations were small at three streams (<30 adults), apparent survival rates ranged from 0.55 ± 0.05 – 0.90 ± 0.05, annual recruitment ranged from 0.02 ± 0.11 – 0.26 ± 0.03, and the oldest frog was at least 13 years. The largest populations were found in intermittent streams and frogs used a variety of habitats. Wild frogs were capable of traveling relatively long distances (e.g., 197 m over 2 days; 1,264 m over 29 days) though they commonly moved little within 4-day surveys (median = 2.2 m/day). At least 52% of 82 released captive-reared adults survived their first summer, and 36% of 22 frogs released in 2017 survived their first winter. Apparent survival of captive-reared frogs was about 40%–60% lower than wild frogs. Captive-raised frogs moved 20%–77% less than wild frogs, and tended to remain close to release pools. Results suggest that reintroductions may be a viable recovery tool, though research is warranted on factors affecting recruitment and survival of younger life stages.

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Research for Restoration and Recovery of a Protected Species: Results of Management Actions for the Southern Western Pond Turtle (*Emys pallida*) in San Diego

The San Diego Field Station of the U.S. Geological Survey (USGS) conducts long-term demographic research to inform recovery and restoration of aquatic protected reptiles and amphibians. One of these reptiles is the southern western pond turtle (*Emys pallida*). One aspect of our pond turtle recovery and restoration research is investigation into the potential positive effect of removal of nonnative aquatic predators. The pond turtle became a protected species under San Diego's Multiple Species Conservation Program (MSCP) in 1997. No successful recruitment of the species was documented on conserved lands within the MSCP area during inventory and baseline surveys conducted between 2002 and 2008. In 2009, USGS with funding from San Diego Association of Governments (SANDAG) and in collaboration with California Department of Fish and Wildlife (CDFW) began a program of experimentally removing nonnative aquatic predators from the Sweetwater River within Sycuan Peak Ecological Reserve (SPER), including bullfrogs (*Lithobates catesbeianus*), largemouth bass (*Micropterus salmoides*), crayfish (*Procambarus clarkii*), and African clawed frogs (*Xenopus laevis*). Following nonnative species removal, wild hatched juveniles were detected at SPER as early as 2010. At the same time, San Diego Zoo's captive rearing program head-started 10 juveniles from eggs harvested from the remaining turtle population; the juveniles were released in 2013 and 2014. By 2019, the combination of wild hatched and captive reared turtles had dramatically shifted the demographics of the previously adult only population towards younger individuals with greater variation in ages (average length 133.0 mm, SD 4.4 in 2009 to 110.0 mm, SD 20.3 in 2019), indicative of a more natural population. With funding from SANDAG and U.S. Fish and Wildlife Service (USFWS), USGS has coordinated with San Diego Management and Monitoring Program (SDMMP) to expand research on removal of nonnative aquatic predators as a management action for western pond turtle to other conserved lands in San Diego County. USGS in collaboration with CDFW, USFWS Partners Program, U.S. Forest Service, and The Nature Conservancy (TNC) has been removing nonnative aquatic predators and has begun to

experimentally restore pond turtles to additional preserves within the SDMMP Management Strategic Plan Area including CDFW's Rancho Jamul ER and TNC's Wheatley Preserve.

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A Fungus Among Us: A Novel Threat to Western Pond Turtles

The Western Pond Turtle (*Actinemys marmorata* and *Actinemys pallida*) is declining throughout its range. In Washington, the Western Pond Turtle (WPT) was saved from extirpation through a variety of recovery efforts, including conservation-breeding and head-starting of hatchlings. However, the successful recovery of the WPT is now threatened by a severe shell disease. A fungal pathogen, *Emydomyces testavorans*, is significantly associated with shell lesions in WPT in Washington and was recently found infecting captive WPT in California. Like many emerging diseases much is not yet known about this shell disease, but collaborative research headed by Washington Department of Fish and Wildlife and supported by the AZA SAFE Program is attempting to better understand the complex relationships involved in the disease. So far, no known cases of the shell disease have been found in wild/free-ranging Western Pond Turtles outside of Washington but thorough surveys have not yet been initiated. This presentation will provide an overview of the disease as we know it so far and lay out current research efforts and needs in an effort to spread awareness throughout the range.

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What is the Best Available Science? Conservation Status of the Inyo Mountains Salamander, *Batrachoseps campi*

Accurate scholarly research is essential for regulatory decisions involving at-risk species, but erroneous or outdated perceptions can complicate data-driven assessments. To interrogate this problem, we used field survey data and a comprehensive literature review to evaluate the conservation status of the Inyo Mountains salamander *Batrachoseps campi*, which is under review for possible listing under the US Endangered Species Act (ESA). Despite uncertainties and limited data, we uncovered many factual errors about the species' status, particularly within the Center for Biological Diversity petition that advocated for ESA listing. Save for evidence of recent flash flood damage to some occupied habitat, which has possibly led to population declines at those localities, no other evidence exists of population declines, population extirpation, or population-scale habitat conversion for *B. campi*. All known populations occur only on federal lands, and many populations have likely benefited from recent federal management targeted at reducing known threats. Of the 12 threats that we identified, only three currently appear to be serious: water diversions, climate change, and flash floods. The remaining threats are neither widespread nor severe, despite contrary claims. We thus evaluate the

contemporary conservation status of *B. campi* as relatively secure, and we recommend its downlisting to Near Threatened on the IUCN Red List. However, ongoing stewardship of this species in a multi-use context by federal agencies remains vital, and we identify several priority management actions and research needs for the species. To maximize the effectiveness of conservation planning, we invite all resource management stakeholders to maintain high standards of scholarship and decision making.

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Effects of Wildfire on a Lentic-breeding Amphibian Assemblage

Although amphibians frequently inhabit wildfire-prone environments, there little known of the effects of fire on amphibian ecology. In addition, amphibians that breed in lentic habitats are presumably less likely to burn due to wetter conditions. We studied the pre- and post-wildfire effects on an assemblage of amphibians at an 11.8 ha seasonal marsh. In 2017 the Nuns Wildfire burned most of the ground cover in the watershed and nearly all marsh vegetation burned to charred and desiccated stubble. Renewal of substantial marsh vegetation occurred after one growing season reflecting the protected rootstock of many perennial wetland plants. All five amphibians known to breed at the marsh were detected post-fire and the western toad (*Anaxyrus boreas*) was first detected at the marsh after the fire. Our estimate of the most abundant species at the marsh post-fire was as high as 19,723 adult California newts (*Taricha torosa*). Overall, the amphibian assemblage appeared resilient to or benefitted from the temporary disturbance of their lentic breeding habitat from wildfire.

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The Co-Occurrence of an At-risk Reptile (*Thamnophis sirtalis*) and an Invasive Amphibian (*Lithobates catesbeianus*) in the South Coast Bioregion: Stranger Danger or Binging on Bullfrogs?

The common gartersnake (*Thamnophis sirtalis*) – southern populations, was designated as a Species of Special Concern by CDFW in 1995. Despite being recognized as an at-risk species 25 years ago, little new information has emerged since. From 2017 to the present we have studied the common gartersnake in Prado Basin (Santa Ana River) in what is now recognized as the largest extant population within Southern California. We determined that the common gartersnake in Prado Basin appears to be thriving in a modified landscape dominated by invasive flora and fauna, with high levels of seasonal disturbance. In the west, the common gartersnake is primarily an anuran predator that historically preyed primarily on the California red-legged frog (*Rana draytonii*) where sympatric. Based on the decline of this native ranid, and our preliminary findings, smaller life stages of the bullfrog (*Lithobates catesbeianus*) appear to be the current dominant prey for larger adult common gartersnakes in Prado Basin. Conversely, it is important to consider that larger adult bullfrogs are predators of younger common gartersnakes due to their smaller size. This interspecific predatory interaction has been termed intraguild predation with role reversal by Polis et al. (1989). Despite occupying different ecological distributions, we

found a zone within the wetland habitat where these two species overlap, where smaller vulnerable sizes would need to balance their needs to forage while avoiding predation. Our overall conclusion at this time is that this common gartersnake population will likely remain viable because it is proving to be extremely resilient where its fundamental ecological requirements are met. Although the presence of the bullfrog is often associated with depressed populations of native amphibians in the southwest, they are now included in the common gartersnake diet. Thus, management plans advocating the removal of the bullfrog should be linked to insuring that an analogous alternative prey is available.

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Slender Salamanders Are Not All the Same: Ecological and Morphological Evolution in *Batrachoseps*

Despite being our most speciose genus of western amphibians, comparative ecological studies of Slender Salamanders (genus *Batrachoseps*) are essentially nonexistent. Here I report results from testing hypotheses to explain species range size disparity, 200 km^2 to over 40,000 km^2, for all 22 described species of *Batrachoseps*. All analyses are considered from an evolutionary perspective, taking phylogenetic relationships into account. *Batrachoseps* show significant and positive niche breadth-range size correlations and abundance-range size correlations. These results are consistent with the niche-breadth hypothesis and occupancy-abundance relationship, respectively. Range size, niche breath, and abundance are also negatively correlated with robustness, owing to elongate species having larger ranges and higher local abundance, species with intermediate morphology showing intermediate ecological values, and robust species generally having small ranges and low abundance. In response to these results a colonization model was used to test whether colonization ability can explain the disparity in range size between species. Colonization ability is significantly correlated with range size under a conservative prediction of spatial aggregation and even stronger when niche breadth is used as a metric for aggregation. These results highlight ecological differences between species of *Batrachoseps* and demonstrate ecological correlations with morphological evolution. Theorized colonization ability, using local abundance and niche breadth as input, is an extremely powerful predictor of species range size.

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Synthesis of 20 Years of Southern California Stream Survey Data into a Macrofaunal Index of Biotic Integrity for Identifying Management Options Across Watersheds

The U.S. Geological Survey with many partners in southern California have been surveying aquatic habitats utilizing standardized protocols for native amphibians, reptiles, and fish to better understand their distribution and conservation status over the last 20 years. Additionally, these surveys include recording data for invasive species such as mammals (beavers, pigs), fish, reptiles (primarily turtles), amphibians, crayfish, and clams. We have been integrating all our databases and conducting QA/QC on these data so that they now can be analyzed by watershed to develop an Index of Biotic Integrity (IBI) based on these macrofauna. We have looked at various watershed scales for southern California to determine what scale seems appropriate for in aggregating data for analyses and interpretation. The Hydrologic Unit Code 12 (HUC 12; https://water.usgs.gov/GIS/huc.html) is the smallest unit mapped for our entire area of interest and was utilized except where small coastal watersheds were clustered within a HUC 12 and then these were pulled out and mapped separately. By taking this watershed approach we can include various other covariates that drive aquatic species diversity, such as natural environmental variability (temperature, precipitation, geology), climate driven variability (drought, wildfire, increasing temperature), and hydrological impairment (dams, groundwater wells, artificial channels). In this presentation we will review the process taken to develop some draft IBI maps for review, some initial analysis, and potential maps highlighting management options across watersheds.

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How Do We Determine When a Cryptic Species is Extirpated versus Not Detectible? The Case of the Desert Slender Salamander (*Batrachoseps aridus*)

The desert slender salamander (*Batrachoseps aridus*) was one of the first species listed as endangered under the Endangered Species Act by the U.S. Fish and Wildlife Service and one of the first species listed under California's Endangered Species Act. It has now been over two decades since a verified sighting of the species has been documented. It remains as the most range-restricted terrestrial amphibian from the west. No new locations for the species have been discovered since 1981. The two known historic locations for this species were surveyed over the last two years, several times each, and during prime activity periods, to determine the status of the habitat at the sites, and to attempt to detect any salamanders. Sampling was done with surrogate species for amphibian fungal disease detection, and remotely triggered cameras were deployed at one site to determine the source of illegal human sign. For both of the field sites, we duplicated methods for direct comparison of field results to either the same observer (Esque) over a 30-year period of time (Guadalupe Canyon) or to a previous thorough California Department of Fish and Wildlife report from 40 years earlier (Hidden Palms Canyon). At neither site were salamanders detected even though 2017 was the first high rainfall year in almost a decade. We additionally discuss the threshold for determining extirpation of a species with very low detectability, especially during an extenuated drought cycle.

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Annual Amphibian Update for California Red-legged Frog, American Bullfrog, Yosemite Toad, and the Sierra Nevada Yellow-legged Frog in Yosemite National Park

The federally threatened California red-legged frog (*Rana daytonii*) was first introduced to Yosemite Valley in 2016. In 2019, captive reared *R. draytonii* at the San Francisco Zoo successfully bred in Yosemite Valley for the first time. A status update will be given for this population in the Valley. An update to the ongoing effort to remove the invasive American bullfrog (*Lithobates catesbeianus*) from historically occupied *R. draytonii* wilderness sites (Swamp Lake & Gravel Pit Lake) will also be provided. We will also discuss the long-term strategy for reintroducing *R. draytonii* at these two locations where bullfrogs may have caused their extirpation. An update on a pilot for the federally threatened Yosemite toad project will also be given. Lastly, we will present results of ongoing restoration efforts for the federally endangered Sierra Nevada yellow-legged frog (*Rana sierrae*).

GRAY, KIM. Curator of Herpetology & Ichthyology, San Diego Zoo Global.

Herpetological Case Studies to Encourage Biologists: The Art of Staying Positive in our Current World

San Diego Zoo Global has been supporting several herpetological conservation initiatives around the world. Kim will present on a few of these projects and provide an overview of how collaborations and partnerships have helped these programs develop and grow, inspiring others through these unique alliances. (Invited after-dinner presentation).

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Twenty Years of Mark-recapture Monitoring of the Amargosa Toad

Nocturnal mark-recapture PIT tag surveys for the Amargosa toad, *Anaxyrus nelsoni*, in Oasis Valley of southern Nevada were conducted consecutively for 20 years starting in 1998. Over 15,000 encounter events were recorded. Surveys combined the efforts of state and federal agency personnel, university staff, and volunteers, including residents of the rural town of Beatty. Data were modeled using Program MARK to estimate population size, survival rates, and interrogated for other demographic and movement patterns. Participation of local officials and members of the community on the Amargosa Toad Working Group (ATWG) built public trust and eventually allowed access to private lands. In 2017 survey efforts were expanded to spring complexes on private lands in the uppermost parts of the Amargosa River, extending the known range of the species. Population monitoring supported the cooperative efforts of the ATWG tasked with implementing a Conservation Agreement Strategy signed in 2000. In 2010, the U.S. Fish and Wildlife Service completed a 12-month ESA review, finding that the listing of the Amargosa toad was not warranted. In 2019 NDOW contracted BIO-WEST to review and evaluate the

Amargosa toad database, and to develop a new database framework (in Microsoft Access). Errors in data recording and transfer over two decades were a challenge, but analyses by BIO-WEST produced similar estimates and patterns to earlier NDOW analyses. Overall, the findings support the perspective that the Amargosa toad population appears robust and relatively stable through time.

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Environmental Training in Captivity Impacts Morphology, Performance, and Post-release Success of Reintroduced Endangered Mountain Yellow-Legged Frogs (*Rana muscosa*)

Reintroductions of endangered species can fail when captive-bred animals are not prepared for natural environments. Pre-release training in captivity can help ameliorate this issue by introducing animals to natural biotic and abiotic challenges. The mountain yellow-legged frog (*Rana musocsa*) is a state, federal, and IUCN-listed endangered species that inhabits montane streams in central and southern California. Most aquarium-based aquatic breeding programs use standard tank setups with a constant but slow flow of filtered water. Because *R. muscosa* inhabits streams that can have high flow, our objective was to test whether exposing captive frogs to faster moving water might better prepare them for their native habitats. We exposed captive one-year-old frogs either to normal tank environments (still/slow-moving water) or to "stream" environments (fast moving water) for five weeks immediately prior to reintroduction into the wild. We measured morphology, jumping performance, and swimming performance before and after treatment. Stream-trained individuals maintained higher ratios of leg to body length. Paired with this morphological difference, stream-trained frogs maintained better swimming and jumping performance across time. Finally, using mark-recapture data, we characterized post-release movement, detection, and survival of reintroduced *R. muscosa*, documenting a weak but positive effect of pre-release training on survival in the months following release. Our results suggest that it may be beneficial to expose captive animals that are destined for reintroduction to conditions that emulate release site habitats.

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Status of the Relictual Slender Salamander (*Batrachoseps relictus*): One of California's Rarest Amphibians

Batrachoseps relictus was described by Brame and Murray in 1968 based on collections of salamanders from the lower Kern River Canyon at the southern end of the Sierra Nevada. Field collections during the period of 1955–1970 revealed salamanders at six discrete locations along the south wall of the Kern River Canyon. These sites corresponded to springs or seepages in an otherwise xeric landscape. However, these populations appeared to die out sometime after 1970, as repeated attempts to find salamanders at these sites have failed. A single high-elevation population at a seep on Breckenridge Mountain, discovered in 1979, appeared to be the last outpost for this species. But in 2001, a field crew from the California Academy of Sciences

discovered a second high-elevation population on Breckenridge Mountain, about 4 km from the first. These two extant sites have a very small footprint (combined habitat < 0.1 hectare) and appear to harbor low numbers of salamanders. Small population size + limited habitat on a montane island + climatic warming = recipe for extinction.

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A Geospatial Tool to Estimate the Reproductive Value of Habitat for the California Tiger Salamander and its Implications for Mitigation Practices

When endangered species habitat destruction occurs, mitigation is often required to compensate for the impacts. Usually, an acreage-based mitigation ratio (e.g., 3:1 mitigation acres to acres impacted) is required without consideration of the quality of the habitat being impacted or conserved for mitigation. Although such simple ratios are easy to quantify and apply, they ignore the existing or potential functions of a particular piece of habitat (Institute of Water Resources 1994). For example, 3 acres of low quality habitat may not compensate for the loss of 1 acre of very high value habitat in terms of value to the species. Quantifying habitat quality for a target species, however, has proven difficult. The challenge is to design a method for assigning habitat quality that is objective, repeatable, rapid, and transparent. Van Horne (1983) suggests that habitat quality can be quantified as "the product of density, mean individual survival probability, and mean expectation of future offspring." This approach assigns value to habitat according to the density of individuals weighted by their reproductive value, or what Searcy and Shaffer (2008) call 'the density of reproductive value'. Searcy and Shaffer (2008) present a model that assigns mitigation credits on the basis of reproductive value to the species. They argue that this procedure is both biologically accurate and general enough to apply to any target species. We created a simple geospatial tool to implement the Searcy and Shaffer model for the California tiger salamander in an effort to improve the mitigation process. The script is spatially explicit and estimates reproductive value for multiple ponds and surrounding upland habitat using an exponential decay function derived from eight years of drift fence trapping and nearly 40,000 individual capture events. The tool helps agency personnel and stakeholders quickly calculate the reproductive value of lands where habitat loss is proposed and lands proposed for mitigation on a biologically-meaningful scale.

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Second Generation Camera Trap (HALT-2) with Innovative Methods for Monitoring Amphibians, Reptiles and Large Invertebrates

Game cameras (Passive Infrared: PIR) are valuable sampling tools commonly used to monitor the use of drift fencing and undercrossings by wildlife but are challenged to reliably sample small animals, particularly those that are ectothermic. We introduce a novel second-generation

active camera trigger system (HALT-2) that enables the reliable and efficient use of wildlife cameras for sampling a vast array of small animals. It far surpasses the detection ability of PIR cameras in monitoring for reptiles, amphibians, and large invertebrates, and eliminates problems such as high rates of false triggers and high variability in detection rates among cameras and study locations. The HALT-2 trigger system couples to a digital PIR camera and is designed to detect small animals traversing constricted pathways such as small culverts and wildlife tunnels. Larger underpasses and culverts can also be effectively monitored for small animals by using the HALT-2 in combination with drift fencing. Internal AA batteries only need to be replaced every 3-4 months depending upon the level of animal activity. We present an example of using the HALT-2 system to monitor California tiger salamander use of road undercrossings in Stanford, California.

HALSTEAD, BRIAN J.[1], JONATHAN P. ROSE[2], and PATRICK M. KLEEMAN[3]*. [1]U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station, Dixon, CA; [2]U.S. Geological Survey, Western Ecological Research Center, Santa Cruz Field Station, Santa Cruz, CA; [3]U.S. Geological Survey, Western Ecological Research Center, Point Reyes Field Station, Point Reyes Station, CA.

An Empirical Comparison of the Efficiency of Time-to-Detection Occupancy Methods to Double-observer and Metapopulation Designs

Occupancy methods are the gold standard for studying species distributions, but they come at a cost: the collection of additional data to account for false absences. The most common occupancy designs require repeat visits to sites or the use of multiple observers. Time-to-detection methods offer a potentially efficient alternative, requiring only one visit to each site by a single observer. We collected time-to-detection data during two different metapopulation design occupancy surveys for four anurans (Yosemite toads, *Anaxyrus canorus*; sierran treefrogs, *Pseudacris sierra*; Sierra Nevada yellow-legged frogs, *Rana sierrae*; and Dixie Valley toads, *A. williamsi*) and compared the performance of time-to-detection methods to the other designs using the location and precision of posterior distributions for occurrence parameters. This comparison allows researchers to evaluate whether time-to-detection methods might be appropriate for their study system. Time-to-detection methods performed as well as the metapopulation design for sierran treefrogs and Sierra Nevada yellow-legged frogs, but traditional methods performed better than time-to-detection for both toads. In general, time-to-detection methods performed best for species that are widespread and have high detection probabilities, but performed less well for cryptic species with lower probability of occurrence or whose detection was strongly affected by survey conditions. Time-to-detection methods are an efficient means of separating the detection process from the ecological process of interest, but their effective use in animals is limited to widely distributed species that are easy to detect. For species with these characteristics, time-to-detection occupancy methods can improve the cost-effectiveness of occupancy studies.

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Dam Removal: Mitigating Impacts and Monitoring the Population Response of Foothill Yellow-legged Frogs

Dams are often dismantled when their age makes them unsafe, obsolete, or economically nonviable. Removal provides an opportunity for river restoration, but demolition presents a challenge in terms of keeping sensitive fauna out of harm's way. Such was the case of the Benbow Dam (South Fork Eel River, Humboldt Co., CA). Constructed in 1931 to generate hydropower, and acquired in 1958 by California State Parks, the dam was operated seasonally to create a 50-hectare lake for recreation until 2008. Foothill Yellow-legged frogs then colonized the river flowing through the former lakebed reaching a peak in 2016 prior to dam removal. To avoid impacts on young of the year caused by dewatering the demolition site, constructing roads, and installing temporary bridges needed to haul 13,000 cubic yards of concrete. Two strategies were employed. In 2016 we relocated eggmasses at weekly intervals via kayak to sites outside the impact zone. Of 538 clutches in the anticipated impact zone, we were able to relocate 90% of them. In 2017 when spring flow conditions precluded eggmass movement, we used temporary block nets and cleared impact zones of tadpoles and frogs at the time of construction in late August. Subsequent surveys indicated that these strategies were successful. Although lek locations shifted in response to sediment movement after dam removal, the abundance of the metapopulation over a wide reach (3.4 km) continues to be robust. Pre-removal, mean (±SE) density was 105±55 clutches per km (n = 4 yr), and post-removal it is 188.9± 3.5 (n = 3 yr).

LODA, JENNY. Center for Biological Diversity, Oakland, CA, jloda@biologicaldiversity.org

An Update on the Center for Biological Diversity's Work to Protect Amphibians in California and Nevada

The Center for Biological Diversity works to secure a future for all species, great and small, especially those hovering on the brink of extinction. The Center has a dedicated campaign focused on the protection of imperiled amphibians and reptiles, and works to obtain federal and state safeguards and protected habitat for herps in California and Nevada and across the country. The Center also works to insure compliance with the Endangered Species Act for species that are already listed under the ESA and uses advocacy at the local, state, and federal levels in its campaign to address the amphibian and reptile extinction crisis. In this presentation, Jenny discusses the Center's work to protect frogs and salamanders in California and Nevada. These include efforts to gain federal and state protections for the foothill yellow-legged frog, three species of Shasta salamanders, western spadefoot, and eight other amphibian species in California and Nevada. Jenny will also discuss the Center's work to fight against projects that will harm rare amphibians and reptiles, including challenges to the expansion of an off-road vehicle park into an area rich with rare herps, and to geothermal development that would harm the Dixie Valley toad's habitat.

LOVICH, ROBERT E.[1]*, and CHRIS PETERSEN[2]. [1]Naval Facilities Engineering Command Southwest, US Navy, San Diego, CA; [2]Naval Facilities Engineering Command Atlantic, US Navy, Norfolk, VA.

Department of Defense Partners in Amphibian and Reptile Conservation (DoD PARC) Summary and Updates

The Department of Defense (DoD) landscape is home to a significant and diverse array of amphibians and reptiles. These species are important for several reasons: they are a part of America's natural heritage, provide valuable indicators of ecosystem health, have scientific and medicinal value, are cultural icons, and in some cases are highly imperiled and legally protected. For over a decade the Department of Defense Partners in Amphibian and Reptile Conservation (DoD PARC) network has provided a platform for conservation and management of herpetofauna on military lands. We present an update on the accomplishments and future direction of this important network, and demonstrate how our projects, products, and people continue to support the training and testing mission of America's military.

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Life History Variation of the Coastal Tailed Frog (*Ascaphus truei*) Across an Elevational Gradient in the Trinity Alps Wilderness, CA

The life history of a species is described in terms of its growth, longevity, and reproduction. Unsurprisingly, life history traits are known to vary in many taxa across environmental gradients. In the case of amphibians, species at high elevations and latitudes tend to have shorter breeding seasons, shorter activity periods, longer larval periods, reach sexual maturity at older ages, and produce fewer and larger clutches per year. The Coastal Tailed Frog (*Ascaphus truei*) is an ideal species for the study of geographic variation in life history because it ranges across most of the Pacific Northwest from northern California into British Columbia, and along its range it varies geographically in larval period and morphology. During a California Department of Fish and Wildlife restoration project in the Trinity Alps Wilderness, we had incidental captures of Coastal Tailed Frog larvae and adults. To date, no population across the species' range has been described above 2000m. These populations in the Trinity Alps range from 150m to over 2100m in elevation, and those that are in the higher part of the range are likely living at the species' maximum elevational limit. In this study, we examined size, growth, larval period, size at sexual maturity, and longevity of *A. truei* across populations along an elevational gradient in the Klamath Mountains of northern California. We calculated growth rates and movement by individually marking tadpoles and post-metamorphic frogs with visual implant elastomer (VIE), then tracking them from May through October of 2018. We described the length of the larval period using length-density histograms to visualize larval cohorts, we determined size at sexual maturity using secondary sexual characteristics of post-metamorphic frogs, and we determined longevity using skeletochronology. We found that the larval period of *A. truei* in the Klamath Mountains of northern California ranges from two years in low and mid-elevations, to at least three years in high elevations. We also found decreased body size of tadpoles, and increased

growth rates of tadpoles and post-metamorphic frogs, with increasing elevation. Post-metamorphic frogs grew at similar rates as previously described coastal California populations. There was high site fidelity and significantly greater movement during the months of June and August in post-metamorphic animals. Frogs in the high elevations are capable of great longevity, with a maximum observed age estimated at eight years post-metamorphosis. The high elevation populations described here have the longest larval period documented in California. This study also provides the first field estimates of larval growth rates and the first longevity estimates of post metamorphic frogs in California. Future laboratory experiments will be necessary to separate phenotypic plasticity of life history traits from true genetic differences between *A. truei* populations in the Klamath Mountains of northern California, as potential explanations for the variation seen.

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Chiricahua Leopard Frog Conservation in Arizona: Status and Challenges

The Chiricahua leopard frog (CLF), federally listed as threatened in 2002, had declined by as much as 80% range-wide at the time of listing, due mainly to predation by nonnatives, die-offs caused by the fungal disease chytridiomycosis (chytrid), and loss and degradation of habitat. The 2007 Recovery Plan outlines a multi-pronged recovery approach that includes habitat restoration, bullfrog control, safe harbor agreements, and captive propagation, all of which have helped reestablish Arizona CLF populations. We have reached significant benchmarks in our progress in CLF conservation in Arizona since 2007, however, some threats, such as chytrid and bullfrogs, have been difficult to mitigate, and CLF recovery in the state will require intensive monitoring and management. We discuss the successes we have had with conservation of this species and the challenges that remain in Arizona and rangewide.

PEEK, RYAN. Center for Watershed Sciences, University of California, Davis, CA.

Beyond an Annual Meeting: A Discussion about Engaging in Amphibian Conservation Outside of January

Engaging in conservation can occur at many levels. The Amphibian Population Task Force has held an annual meeting for many years, from which many collaborations, conversations, and projects have likely stemmed. However, the ATPF group may be able to better engage in amphibian conservation at local and regional scales beyond a single annual meeting if there are individuals motivated and willing to help coordinate some specific achievable tasks. We'll have a chance to discuss some of the potential options/opportunities Brad Shaffer brought up at last year's meeting, and take a look at the survey feedback we received from APTF members. We recognize everyone has limited time and energy, but we'd like to know if this group wants to be more active beyond the annual meeting. If so, we can discuss and describe some discrete opportunities for outreach/engagement/action and identify people motivated to coordinate/participate.

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California Red-Legged Frog (*Rana draytonii*) Pond Construction and Maintenance in Baja California, Mexico

The California Red-Legged frog in Baja California is only known to occur in 10 remnant sites, representing four genetic populations. Habitat loss, pollution, invasive species, drought, agriculture, and disease have led to local extinctions across historic sites at both high and low elevations. In an effort to improve the resiliency of the existing populations we are building and maintaining ponds in areas adjacent to creek habitats. This model of pond construction has been used throughout northern California with great success and our initial results indicate that the technique also works well in Baja California. Two ponds were built at Rancho Meling in August 2018; within a year we have found that California Red-Legged frogs are able to quickly colonize them. The ponds are dug at a depth that allows them to fill naturally by groundwater infiltration, and we anticipate breeding activity in the ponds in 2020. Two smaller ponds were built in November 2019 at a second locality. We discuss the challenges and successes of our pond construction efforts as well as our plans for future habitat improvement efforts.

RICHMOND, JONATHAN Q.*, DUSTIN A. WOOD, ADAM R. BACKLIN, ELIZABETH A. GALLEGOS, ANNY PERRALTA-GARCÍA, JORGE H. VALDEZ-VILLAVICENCIO, and ROBERT N. FISHER. U.S. Geological Survey, Western Ecological Research Center, San Diego CA.

The Mystery of Whitewater Canyon: A Tale of Survival for the Declining California Red-legged Frog *Rana draytonii* in Southern and Baja California

Discovery of living populations of a species in decline can generate new optimistic narratives for conservation in geographic regions suffering from losses in biodiversity. Southern California is now infamous for its high number of threatened and endangered species, with amphibians experiencing some of the most severe declines since the 1960s. In 2017, a population of the threatened California red-legged frog *Rana draytonii* was discovered in Whitewater Canyon, a south facing drainage in the San Bernardino Mountains of Southern California, where the species was presumed to be extirpated. Several explanations for the emergence of this population were feasible: (1) it was there all along, but the presence of trout and a robust raccoon population kept the frogs below a detectability threshold; (2) trout removal and raccoon population thinning provided an opportunity for frogs to colonize the area from nearby sites; (3) clandestine herpetoculturists transplanted the frogs from an unknown location. In this talk, we present the results of a genomic study used to pinpoint the source of these frogs and discuss a potential role for this population in restoring the species at extirpated localities. This study presents an interesting dilemma for managing and conserving *Rana draytonii* in the southern portion of its range, where extirpation of local populations is widespread and extends across the international border with México.

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Environmental DNA (eDNA) Sampling as a Method to Detect Rare or Elusive Aquatic Herpetofauna: Two Case Studies

Restoration projects with potential to support protected species must consider these species at each stage in the process, from planning and permitting to implementation and performance monitoring. Traditional survey methods to detect protected species can be labor and time intensive and may not provide accurate results at site specific resolution. This is especially true for cryptic species, when population abundance or density is low, and when conditions limit traditional sampling or affect sampling consistency. Environmental DNA (eDNA) sampling, when properly implemented, can greatly reduce field efforts and provide additional confidence of species presence or absence at a site. Knowledge of species presence during design and permitting can be instrumental to an effective project especially if non-target protected species may be present and need consideration. This method can also be an effective way to supplement traditional survey methods by identifying focal areas when detection probability is low. In this presentation, we introduce eDNA and associated sampling methods, provide applications for its use, along with benefits and caveats of this method. We offer two case studies to show practical applications of eDNA sampling as (1) a supplement to traditional survey methodologies when species abundance is low (e.g., California tiger salamander [*Ambystoma californiense*]), and (2) a study directly comparing traditional survey methods with eDNA based on species-specific quantitative PCR (qPCR) and multi-species metagenomic analysis.

SHAFFER, H. BRADLEY*, ERIN TOFFELMIER, EVAN MCCARTNEY-MELSTAD, and KEVIN NEAL. Department of Ecology and Evolutionary Biology and La Kretz Center for California Conservation Science, UCLA, Los Angeles, CA, brad.shaffer@ucla.edu.

Population Genomics of California Amphibians and How it Informs Conservation

Over the past several years, our lab has been refining our ability to construct high-resolution genomic data for a range of Californian amphibians (and reptiles) and apply these data to conservation actions. In this talk, we will briefly summarize our recent work on three declining species: the foothill yellow-legged frog (*Rana boylii*), western spadefoot (*Spea hammondii*) and the critically endangered Santa Barbara Distinct Population Segment of the California tiger salamander (*Ambystoma californiense*). In the final part of this presentation, we will discuss a newly funded project, the California Conservation Genomics Project, explain its goals, and begin a discussion of key species of reptiles and amphibians that would be useful to include.

SWEET, SAMUEL S. Department of Ecology, Evolution, and Marine Biology, University of California, Santa Barbara, CA.

Rediscovery and Status of the Santa Lucia Salamander *Batrachoseps minor*

This small salamander was easily collected in the early 1970s then apparently became scarce, with only 5 individuals recorded in the 35 years between 1975 and 2011. What we know as *Batrachoseps minor* was recognized as sympatric with *B. nigriventris* by Richard Pimentel in

about 1960 and named as one of four isolates of *B. relictus* by Brame and Murray (1968), then separated off as *B. minor* by Jockusch, Yanev and Wake in 2001. Starting in 2011 I returned to the 1970s collecting sites and found them at all but the three most marginal. I also filled in gaps, and extended their range to the SE. Neither *Batrachoseps* species is as common now as during the wet years of the 70s, and *B. minor* is perhaps more ecologically restricted. In comparison to the narrowly parapatric habitat generalist *B. nigriventris*, *B. minor* prefers NE-facing slopes of 40-80°on shallow soils with thin leaf litter, exposed bedrock and >80% canopy closure, and is almost restricted to patches of poison oak with stem densities of 20-40/m². I believe the latter is largely responsible for the view that the species had become rare. The USFWS is evaluating a petition to list *B. minor* that is factually incorrect in every specific cited; in my view listing would have no benefit whatsoever.

WESTPHAL, MICHAEL F.*, and EMMELEIA NIX. US Bureau of Land Management, Marina, California; mwestpha@blm.gov.

Resurveys for Foothill Yellow-legged Frog, *Rana boylii*, in the Southern Diablo Range

A set of watersheds converging on San Benito Mountain in the southern Diablo Range of San Benito County, California represent an important refuge for *R. boylii* and may constitute the sole remaining viable metapopulation in the inner coast ranges south of San Francisco Bay. A set of creeks in the region were surveyed by US Bureau of Land Management and US National Park Service in 2006-2007 and significant populations of *R. boylii* were documented in most of them. Twelve years later we conducted targeted resurveys of the creeks and confirmed the persistence of breeding populations in all of them. We propose that the BLM-managed populations of *R. boylii* in the south Diablo Range may provide a crucial source for repatriating the species throughout the southern portion of its range.

POSTER PRESENTATIONS

BREHME, CHERYL S.[1], JEFF A. TRACEY[1], BRITTANY IDRIZAJ[1], MICHAEL HOBBS[2], ALAN LAUNER[3], and ROBERT N. FISHER[1]. [1]Western Ecological Research Center, U.S. Geological Survey, San Diego, CA, cbrehme@usgs.gov; [2]Wildlife Ecologist, Technologist, San Jose, CA; [3]Associate Director, Conservation Planning, Stanford Conservation Program, Stanford University, Stanford, CA.

Effects of Fence Opacity on Movement of California Tiger Salamanders Toward an Underpass System in Stanford, CA

There is recent evidence that road mitigation systems with inadequate underpass spacing between uplands and breeding ponds may result in population declines in pond breeding amphibians. The common toad, *Bufo bufo*, in the Netherlands were shown to turn around or "give-up" after an average of 50 m if they did not reach an underpass. We were interested if this behavior is exhibited pond breeding amphibians in California to inform underpass spacing for

the California DOT (Caltrans). We were also interested if the opacity (solid vs. transparent) of barrier fencing affects animals' movement speed or give-up distances, and if 'turn-arounds' at fence ends are effective in altering the trajectory of movement. We studied the movement of California tiger salamanders (CTS; *Ambystoma californiense*) adjacent to three existing underpasses along Junipero Serra Blvd in Stanford, CA (Stanford University) in the winter breeding seasons of 2017/18 and 2018/19. The road bisects a historic CTS breeding pond (Lake Lagunita) and upland CTS habitat. Approximately 125 m of exclusion fencing was installed on each side of the underpass entrance with 1.5 m x 3 m turn-arounds at the fence ends. On the same side of the road, one side of the fencing installed was semi-transparent and the other side was solid. HALT active trigger cameras were set along the fence lines every 25 m to capture photos of animals moving along the fence line. Photos were then analyzed using pattern recognition software to identify individuals by their unique spot patterns. Location, time and direction of movement were recorded for each individual. In the second year, we also monitored movement through the underpasses with HALT cams installed in both sides of each underpass. We present preliminary results from this study that include average distances, speed, and direction changes of CTS along the different fences and through the underpass structures. This study is part of a larger research program in collaboration with the Western Transportation Institute (WTI; Montana State University) for the California Department of Transportation (Caltrans) to inform best management practices for barrier and crossing systems for sensitive amphibians and reptiles in California.

CHELLMAN, ISAAC C.*, MITCH T. LOCKHART, and SARAH MUSSULMAN.
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Translocating Sierra Nevada Yellow-legged Frogs (*Rana sierrae*) to Establish a New Population in the Upper Rubicon River Watershed of Desolation Wilderness, California

One of the last strongholds for northern populations of endangered Sierra Nevada Yellow-legged Frogs (*Rana sierrae*) is Desolation Wilderness. Recent surveys and mark-recapture studies have revealed population recovery in some areas, but range-wide prospects for species persistence are still uncertain. Therefore, an interagency team is working to help restore *R. sierrae* populations. In July 2018, we collected 60 adult *R. sierrae* (26 males, 34 females) from a large population in Desolation Wilderness and translocated the frogs to a nearby fishless lake basin with no recent *R. sierrae* detections. To allow identification of individuals, we PIT-tagged each frog prior to translocation. We revisited the recipient site twice in 2018, during which we observed 22 of the 60 translocated frogs. In August 2019, we surveyed the recipient site and detected nine individuals translocated in 2018 (4 males, 5 females). Two days later, we translocated another group of 40 adult *R. sierrae* (18 males, 22 females) using identical methods. One month after the second translocation, we surveyed the recipient site and observed 19 of the 100 translocated frogs (9 males, 10 females), four of which were translocated in 2018. Our goal is to help create an interconnected *R. sierrae* metapopulation in the upper Rubicon River watershed by establishing a new breeding population in northwestern Desolation Wilderness. Translocations like those described here have been informed by ongoing research, the initial results of which suggest these actions may help *R. sierrae* populations persist in fishless habitats, despite presence of the fungal pathogen *Batrachochytrium dendrobatidis*.

CURTIS, MICHELLE J.[1]*, TALISIN T. HAMMOND[1], LEAH E. JACOBS[1], NATALIE E. CALATAYUD[1], CANDACE L. WILLIAMS[1], ABBEY E. WILSON[2], RONALD R. SWAISGOOD[1], and DEBRA M. SHIER[1]. [1]San Diego Zoo Institute for Conservation Research, Escondido, CA, mcurtis@sandiegozoo.org; [2]University of Saskatchewan, Saskatoon, SK, Canada.

Increasing Survey Efficiency and Detection Rates of an Endangered Amphibian

Reintroductions and translocations have become a key component of many amphibian conservation efforts. In order to evaluate and optimize reintroduction methods, it is critical to conduct post-release surveys in which reintroduced animals are reliably detected. However, it can be challenging to detect and monitor amphibians, which are often rare and cryptic, using traditional visual survey techniques. Here, we discuss novel and traditional detection methods employed during mountain yellow-legged frog (*Rana muscosa)* post-reintroduction surveys for larval, metamorph, and adult life-history stages. We reintroduced captive-bred individuals into multiple field sites in southern California and conducted post-release monitoring using six detection methods: visual surveys, camera traps, a long-range PIT tag reader, scent detection canines, nocturnal surveys, and radio-telemetry. We qualitatively compare the efficacy of each tool, discussing pros and cons and, where possible, presenting information on detection rates. The feasibility and utility of each detection method depends on habitat type, population traits, life-history stage, available resources, and the question being explored. For example, high resolution camera traps successfully record activity patterns of *R. muscosa* at higher density sites, making them most effective at recent reintroduction locales or at locations with known inhabitants, while scent detection canines may be more effective at identifying the presence or absence of frogs, making them suitable at sites with low population numbers. Our preliminary results provide valuable direction regarding the contexts in which each detection method may be most suitable, and highlight new technology that may be useful to other amphibian conservation programs.

HITCHCOCK, CYNTHIA J.[1]*, ELIZABETH A. GALLEGOS[1]*, ADAM R. BACKLIN[1]*, and ROBERT N. FISHER[2] *in collaboration with:* Russell Barabe, Peter Bloom, Kimberly Boss, Cheryl S. Brehme, Christopher W. Brown, Denise Clark, Kevin Cooper, Elizabeth Clark, Julie Donnell, Edward Ervin, Peter Famolaro, Kim Guilliam, Jaquelyn Hancock, Nicholas Hess, Robert Hess, Steven Howard, Valerie Hubbartt, Patrick Lieske, Tritia Matsuda, Kathy Meyer, Kamarul Muri, Barry Nerhus, Jeff Norland, Brock Ortega, Robert Packard, Samuel Stewart, Samuel Sweet, Jeffrey Wells, Kirsten Winter, and Brian Zitt. [1]U.S. Geological Survey, Western Ecological Research Center, Santa Ana, CA, chitchcock@usgs.gov; [2]U.S. Geological Survey, Western Ecological Research Center, San Diego, CA.

A Summary and Current Status of the Arroyo Toad (*Anaxyrus californicus*), Twenty Years After the Recovery Plan

The arroyo toad has been listed as endangered since 1994. Multiple organizations have been collaborating to protect and recover this species for the past 25 years; however, these organizations are still trying to stabilize and prevent populations from continued declines.

Prolonged drought exacerbates this problem. We compiled the most recent collaborative data available on arroyo toad populations for the 25 known occupied or once-occupied watersheds in southern California. Many of the populations within these watersheds have been recipients of management and protection. Some populations appear to be stable and self-sustaining, some are sustaining with continual management, and others continue to decline and have disappeared. Data were available from 23 of the 25 watersheds surveyed in 2017. Twenty-plus years of collaborators monitoring for arroyo toads have provided an extensive background and overview for the occupancy of this species within each of three recovery units delineated in the Recovery Plan (created in 1999). By associating presence/absence from the 2017 surveys with the distinct locations requiring occupancy for the Recovery Plan, we found that 1) for the seven populations in the Northern Recovery Unit, data are missing for two key locations but all other locations are occupied, 2) for the southern Recovery Unit, all populations delineated in the Recovery Plan are occupied, and 3) for the Desert Unit, only one of the populations delineated in the Recovery Plan did not have arroyo toads. These data show that most populations have persisted through extreme drought, but several key locations may need attention to recover this species.

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Identifying Individual California Tiger Salamanders *(Ambystoma californiense)* (CTS) Using Pattern Recognition Software

Identifying individual California tiger salamanders *(Ambystoma californiense)* (CTS) normally requires methods that involve mutilation, tail and toe clipping, or insertion of passive integrated transmitter (PIT) tags into the abdominal cavity. These methods can be risky, decreasing an individual's health and survival rate. To reduce these factors, we looked at a method that used the unique color patterns of each CTS to reliably identify individuals. The computer program Interactive Individual Identification System Pattern Plus (I3S+), was used to achieve this. I3S+ was found to successfully identify individual CTS faster and with more ease than the human eye could. I3S+ accomplished this by using the unique spacing, size and shape of each individual's pattern to see how similar the patterns of a CTS are to the other CTS photos in the database. The ability to more accurately identify individuals allows us to help better understand the population dynamics of the CTS, while decreasing the risk and harm to the salamander. Being able to also compare the individuals between ponds that are within close proximity (< 1km) with the I3S would provide more insight into the spatial movements of CTS.

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Salvage and Translocation of Endangered Santa Cruz Long-toed Salamander (*Ambystoma macrodactylum croceum*) Larvae

In 2012, the Resource Conservation District of Santa Cruz County constructed a pond for the Santa Cruz long-toed salamander (*Ambystoma macrodactylum croceum*) on the Willow Canyon Unit of the Santa Cruz Long-toed Salamander Ecological Reserve in southwest Santa Cruz County, California. Although the pond provided suitable breeding habitat, annual aquatic sampling from 2013-2016 did not confirm breeding or subsequent colonization. From 2016-2018, we salvaged *A. m. croceum* larvae from a shallow drainage channel along California State Route 1 adjacent to the Valencia Lagoon Unit of the Reserve. The larvae were translocated 1.0 km to the constructed pond, as these animals were threatened with stranding and desiccation. Upland habitat connectivity between the locations is compromised by low-density residential development, although the best available genetic data demonstrates common ancestry among ponds within this population cluster. Over three consecutive years, a total of 947 larvae were translocated. Following the first-year transfer of 300 mid- to late-stage larvae (average 69 mm TL, range 30-80 mm), which ended on 2 June 2016, we placed plywood coverboards at the edge of high water and checked them daily from 21 June to 15 August 2016. Post-metamorphic juveniles (n=46) were measured (n=34), weighed (n=32), and moved approximately 10-30 m out of the aquatic system to moist leaf litter in nearby uplands under mature willow (*Salix* sp.) and coast live oak (*Quercus agrifolia*) canopy. Aquatic sampling at the Willow Canyon Pond on 23 April 2019 determined that larvae were abundant, concluding the relocation project. On 27 September 2019 adjacent to the drying pond, 20 post-metamorphic juveniles were observed under woody debris indicating that Santa Cruz long-toed salamanders successfully bred and metamorphosed at the constructed pond for the first time.

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Arroyo Toad Population Status in the Southern Orange County Subregion Habitat Reserve

The arroyo toad population in the Southern Orange County Subregion Habitat Reserve (Habitat Reserve) is one the largest extant populations of the federally endangered species occurring outside of public lands. As a Covered Species in the Southern Orange County Subregion Habitat Conservation Plan (SSHCP), arroyo toad habitat is conserved through the phased dedication of Rancho Mission Viejo (RMV) lands into the Habitat Reserve. The arroyo toad population in San Juan Creek has also benefitted from invasive species controls conducted under the SSHCP including 110 acres of giant reed (*Arundo donax*) removed from San Juan Creek (SJC) from 2010-2018. The Habitat Reserve currently includes 18 km of arroyo toad habitat in the SJC watershed, including 13.5 km on public lands within Caspers Wilderness Park, and 4.25 km on dedicated RMV lands. At full enrollment, habitat in the Habitat Reserve would increase to approximately 33 km with an additional 15 km on RMV lands in Cristianitos Creek, Gabino Creek and Talega Creek within the San Mateo watershed. Prior to initiating presence/absence monitoring in 2017, the status of the population in SJC had not been confirmed for 11 years, a period spanning the extended drought from 2011-2016 when suitable breeding conditions were not present in the creek. Presence/absence monitoring conducted in 2017 and 2019 estimated occupancy in surveyed areas to be 96% (SE ± 0.09) and 89% (SE ±0.04), respectively. In 2019, a nearly five-fold increase in egg clutches observed relative to 2017 indicated a substantial increase in reproductive females in the population.

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Conservation Challenges in Recovery of Imperiled Flatwoods Salamanders

Flatwoods salamanders (*Ambystoma cingulatum* and *A. bishopi*) have declined by nearly 90% due to loss, degradation and fragmentation of their habitat. In 2014, USGS initiated a long-term management strategy for the frosted flatwoods salamander (*A. cingulatum*) at St. Marks National Wildlife Refuge, Florida. Our strategy consists of 1) restoration of both upland and wetland habitat; 2) head-starting of aquatic larvae; 3) capture-mark-recapture of terrestrial adults and juveniles; and 4) annual surveys of historically-occupied sites. From 2016 to 2018, we reared more than 1000 larvae in aquatic mesocosms and released more than 700 juveniles at their natal sites. A total of 450 adult and juvenile salamanders have been captured and marked, with 62 individuals recaptured in subsequent years. Twenty to 55 historically-occupied wetlands have been surveyed for larval occupancy annually since 2014 and occupancy appeared to be stable until October 2018, when storm surge from Hurricane Michael pushed sea water into many coastal wetlands in which this species breeds. Although <40 live adult salamanders were found in a few pond basins immediately after the storm and again in Fall 2019, few aquatic larvae were detected during occupancy surveys in Spring 2019. These effects illustrate the vulnerability of this species to stochastic, environmental perturbations, exacerbating its risk of extinction. Until it was affected by the hurricane, St. Marks was a stronghold for *A. cingulatum*; thus, recovery of this population is vital to preventing further risk of extinction elsewhere in this species' historical range.

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Mitigation Ponds Offer Drought Resiliency for western Spadefoot (*Spea hammondii*) Populations.

In southern California, more than 80% of western spadefoot (*Spea hammondii*) habitat has been lost to development. To mitigate a proposed development at East Orange, Glenn Lukos Associates, Inc. created western spadefoot breeding habitat and translocated western spadefoot tadpoles in 2005 and 2006. The two mitigation sites, Shoestring Canyon and Irvine Mesa, were located within 5 miles of East Orange and were monitored by Glenn Lukos Associates, Inc. annually until 2010. The U.S. Geological Survey conducted surveys in 2016-2019 to 1) determine if adult spadefoot were present at all three sites, 2) determine if the pools were used for spadefoot breeding, and 3) if the pools were used for breeding, to verify that the hydroperiods were long enough (30 day minimum) to allow the spadefoot tadpoles to reach metamorphosis. During the winter of 2016 no pooling water or spadefoot were detected at East Orange or Shoestring Canyon. Twelve of the 14 pools at Irvine Mesa held water for over 30 days and had successful breeding at seven pools. In 2019, Irvine Mesa and Shoestring Canyon had successful breeding and full recruitment of spadefoot. The success of the mitigation effort at Irvine Mesa

indicated that spadefoot habitat can be created and support western spadefoot for 13+ years if all the required factors such as soil, plant community, and climate were in place.

* Indicates presenter in multi-authored presentation