Mountain Lakes Research Group 2023 Newsletter

University of California Sierra Nevada Aquatic Research Laboratory

Using science to solve management challenges in California's Sierra Nevada lake ecosystems, with a focus on recovering endangered mountain yellow-legged frogs

PC: Forest Peri

Winter 2023 was a season for the books. Multiple atmospheric rivers blanketed the Sierra Nevada in snow unlike any other year on record, delivering a snow pack that was 250 to 400 percent of normal in different regions of the Sierra. At Mammoth Mountain, more snowfall was recorded than in any previous winter in recorded history. And the snow stayed due to unprecedented cold temperatures; some regions in California experienced the coldest winter in 30 years. In the Eastern Sierra, highways closed from avalanches and flooding, and buildings were damaged and destroyed, but reservoirs filled in the spring, skiers rejoiced, and snow shovelers made $80 per hour.

What does a winter like this mean for mountain yellow-legged (MYL) frogs? We didn't know what to expect. We began our field season in mid-July, post-holing through snow as we traveled to sites. During the summer, we came to expect the unexpected. During a survey of a reintroduced MYL frog population, we witnessed a large snow bank calve off the shore and send a small tsunami across the lake. At other sites, we encountered 30 foot cliffs of snow dropping straight into lakes, challenging our best efforts to conduct surveys. However, throughout the summer we were pleased to find that MYL frogs are even hardier than we expected. At most of the lakes we visited, we captured a similar number of adult frogs as we have in the recent past. We observed frogs breeding in August. And despite the short summer, we still **visited 107 lakes, reintroduced close to 300 adult frogs, and collected 700 tadpoles** for future reintroductions. Read on for season highlights, a conservation success story, a funding overview, and acknowledgements to our devoted partners, collaborators, and seasonal staff biologists without whom this research could not take place.

2023 Highlights

Reintroductions. We reintroduced almost **300 adult frogs** in 2023. We released frogs into eight different lakes spread across three national parks and one national forest. These frogs were collected as tadpoles from populations that are persisting with the often lethal chytrid fungus, and were reared to adulthood at the Oakland and San Francisco Zoos. Frog transport was facilitated by agency and zoo partners.

Collections. In preparation for 2024 and 2025 reintroductions, we and our partners collected over **700 tadpoles** at seven sites in Yosemite and Kings Canyon National Parks and the Sierra and Inyo National Forests. Under the diligent care of our zoo partners, many tadpoles have already metamorphosed into subadult frogs.

RIBBiTR. As members of the Resilience Institute Bridging Biological Training and Research (RIBBiTR), we collaborate with biologists and educators across nine universities to understand resilience to disease in amphibian populations. In 2022, we began collecting environmental data and biological samples from frogs following the same protocols as other researchers studying amphibian declines in Pennsylvania, Panama, and Brazil. We continued this sampling effort in 2023, collecting almost **400 samples** from frogs to learn more about frog immune defenses and how frog genetics affect the ability of frogs to persist with the amphibian chytrid fungus. We helped deploy acoustic recorders and collected eDNA samples to measure how amphibian communities influence disease outcomes and how amphibian declines affect mountain lake communities. To understand the effects of microclimate on amphibian disease, we deployed weather stations and captured thermal images of frog habitat. We are excited to leverage these samples to learn more about amphibian resilience in the Sierra Nevada and globally.

The Numbers

291 frogs reintroduced

700 tadpoles collected

107 lakes surveyed

2398 adult MYL frogs observed during visual surveys

1930 subadult MYL frogs observed during surveys

60,300 MYL frog tadpoles observed during surveys

1132 skin swab samples collected

398 RIBBiTR immunology samples collected

11 weather stations deployed and collected

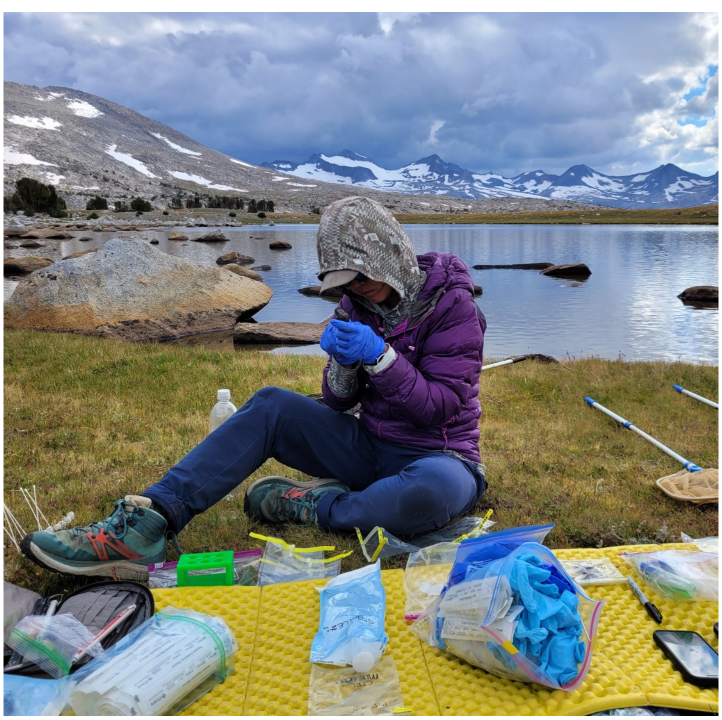
>800 survey hours

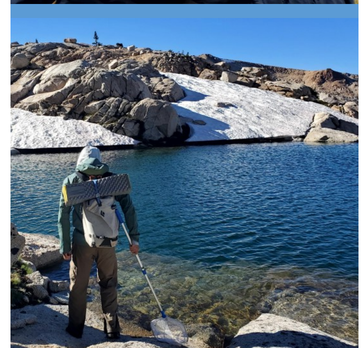
6 helicopter landings

5 seasonal technicians

3 permanent employees

Miles walked? Elevation gained? We'll never tell...






PC: Sara Dykman

Science and Conservation together: why frog translocations work.

Amphibians around the globe are declining from the novel amphibian fungal pathogen, *Batrachochytrium dendrobatidis* (*Bd*). *Bd* invades amphibian populations that have never been exposed to the pathogen (i.e. "*Bd*-naive"), and a disease outbreak ensues. Without a history of co-occurrence with the pathogen, *Bd*-naive populations lack immune defenses to fight infection, making *Bd* lethal for many species. Outbreaks can have devastating and irreversible consequences for amphibian populations, including local extinction.

Once it invades, *Bd* remains in water bodies even if its amphibian hosts are long since gone. This presents a significant challenge for efforts to recover endangered amphibians that are susceptible to *Bd*, and has stymied past attempts to reestablish locally extinct populations. Seeking to recover a population decimated by *Bd*, scientists and land managers have reintroduced amphibians collected from another nearby *Bd*-naive population, only to witness those newly introduced individuals succumb to the same fate. But after an 18 year study on reestablishing mountain yellow-legged (MYL) frogs in the Sierra Nevada, we are proud to share a success story in amphibian conservation. The key to our success? Frog evolution and two decades of collaboration among academic, non-profit, and agency scientists.

Mountain yellow-legged frogs are endangered due to (1) the introduction of non-native trout into their largely fishless habitat, and (2) the invasion of *Bd* in the Sierra. While trout can be removed from some MYL habitats, resulting in rapid recovery of frog populations, *Bd* cannot be removed from the landscape. As such, MYL frogs must overcome the pressures of this pathogen to recover.

Although most MYL frog populations experience local extinction after the arrival of *Bd*, some populations have persisted despite ongoing infections. Interestingly, frogs in these populations show increased resistance to *Bd* (i.e. the ability to limit the severity of *Bd* infection). In a new study, we show that this resistance is the result of evolution in frogs. The genomes of frogs persisting with *Bd* differ from genomes of *Bd*-naive frogs. Some of these differences lie in gene regions associated with immune function and disease resistance in other taxa.

This study also describes how, over the past 18 years, we leveraged the evolution of resistance to *Bd* in these populations to recover MYL frogs through reintroductions. We collected frogs from one of three *Bd*-persistent populations and reintroduced them into 12 sites that were empty of frogs due to past *Bd* outbreaks. At nine of these 12 sites, we observed successful reproduction (tadpoles and juveniles) and recruitment of new adults. In addition, results from mathematical models indicate that the majority of reintroduced populations will likely persist over the long term without additional human intervention. By reintroducing resistant frogs into habitats they formerly occupied, we can reestablish MYL frogs in the presence of *Bd* across their historical range. Armed with this powerful recovery tool, we will require multi-agency collaboration, patience, and adequate funding to continue reestablishing MYL frogs in the Sierra.

MLRG in the press.

For more information on this reintroduction success story, read the study preprint and popular press coverage in New Scientist. Zooming out, an article by Earth Justice highlights the importance of MYL frog species listing and recovery actions to Sierra Nevada conservation. Byrne et al. 2023 revisits genetic groupings of MYL frogs with broader sampling and updated techniques to inform MYL frog conservation. For a cool intersection of natural history and machine learning, read Lapp et al. 2024 to learn more about MYL frog calls. To learn more about the historical effects of Bd on Yosemite toads, another listed Sierra amphibian, check out Dodge et al. 2024.

Tom Smith, Juyung Yoo, and Anna Dieffenbach take an evening stroll after a long day of surveying. Photo credit: Maya Lapp.

Wishlist

Your used smartphone! ($0) [Link](#) for details

100 PIT tags to track individual frogs ($165)

Pay the rent for our office & lab spaces at SNARL for one month ($995)

Immunize frogs at the Oakland Zoo ($3000)

Fund a field technician for the summer ($12,500)

Purchase a second qPCR machine, which allows us to provide at-cost disease testing for agencies and academics ($24,000)

Help fulfill the dream of an endowment to fund frog recovery and lake research in perpetuity! ($10 million - yes, we dream big)

Supporting Mountain Lakes Research

Our frog research and recovery work are 100% grant and gift funded. We have leveraged these funds to accelerate frog recovery in ways we never expected. We rely on this support to pay our salaries and benefits, to mentor our incredible field teams, and to provide actionable research results to our conservation partners. We look forward to sustaining our current funding relationships and to growing relationships with new donors and funding programs. If you are in a position to make choices or recommendations about where people or organizations can direct their dollars, and you or your organization value biodiversity, conservation, ecosystem integrity, and endangered species recovery, please keep in mind the needs and productivity of our research and recovery program. We provide an excellent return on investment, if your metrics include number of young scientists trained or number of frogs and frog populations across the Sierra Nevada.

We also suggest this: share with people in your network your own love of the Sierra, its flora and fauna, and the importance of the connections between them and all of us. Contact your US Senator or Rep about supporting the Recovering America's Wildlife Act. Inspire others to invest in or vote for the future of this mountain range that we rely on for water, recreation, and well-being.

In 2024, we were funded by grants from the National Science Foundation, U.S. Fish and Wildlife Service, the National Park Service, and California Department of Fish and Wildlife. We are honored to be supported by gifts from Sequoia Parks Conservancy, Yosemite Conservancy, and private individuals and their employers' donation matching programs. We especially thank our donors who give annually; you support standard programmatic costs and unforeseen costs like equipment failure or wages for staff during challenging but finite projects. If you would like to join our support network, start with our Wish List to see what your donation could support. To make a financial contribution, please contact Tom or Roland and Jessica Ajao at the Earth Research Institute (proposals@eri.ucsb.edu). UCSB is a non-profit organization; some donations may be eligible for employer-matching; overhead on your gifts is relatively low (6%). Nearly all of your dollars will be used to train the next generation of conservation biologists and to continue critical frog recovery actions.


Snow cave reflection. PC: Forest Peri.

I leave my car and catch a ride north
As I step out of the truck to tie my shoes, the sky darkens to black and opens up
Heavy drops of water beat down
Starting a loud but tranquil white noise
I apologize to my back and knees and sling my heavy pack over my shoulder
And with that, I ramble out into the storm to start a trek through the mountains
The landscape is alive
The trail rushes with water, a temporary flowing stream
The branches of the lodge poles bounce up and down, excited by the falling rain
The lakes are stippled by thousands of small radiating circles
A gentle pitter patter
A large group of pine trees stand beheaded
A natural execution
The sweet aroma of pine fills my nostrils
An avalanche has ripped through this forest
Remains of trees litter the ground
The almighty ice and snow has relaxed and returned into the lake, leaving no trace of itself, but the splintered trees, torn in two
A piece of sky lightens as the sun attempts
To push through
The clouds push back, but the sun succeeds,
Sending a bright beam of light down to the ground
And like that,
As if the storm gave up,
The clouds lift and large patches of sky turn blue
Beads of water hang from the pine needles,
Illuminated by the sun, shining bright like liquid diamonds
Chickadees and juncos chirp and chatter in the trees
Jumping and fluttering from limb to limb
Releasing the sparkling jewels, which hastily fall to the ground
Crumbling granite forms tall peaks that dominate the skyline in every direction
Resilient patches of snow linger stubbornly on portions of the mountain slopes
Covered in red algae and textured with sun-cups
Up a mountain
Over a pass
Down a mountain
Red, pink and white flowers are scattered along a portion of stream
An example of a rare phenomenon
A hybridization between two columbines
A botanists delight
And a beautiful sight

- Excerpt. Forest Peri, Field Technician, 2023

Acknowledgements. Our research would not be possible without our partners and donors. A big thank you to all those who made the 2023 field season possible and safe following the biggest snow year on record. We specifically thank our summer field technicians Anna Dieffenbach, Maya Lapp, Sage Lee, Forest Peri, and Juyung Yoo for their flexibility, hard work, and good conversation in the backcountry; John Imperato, Sage Lee, and Kira Miller for their assistance in the qPCR lab; and Carol Blanchette and many other staff at the UC Santa Barbara Natural Reserve System and our administrative support from UCSB Earth Research Institute for providing support for our lab and field work during 2023. We thank our zoo, park service, forest service, and state and federal fish and wildlife partners for their dedication to amphibian conservation and joint efforts in permitting, planning, funding, and field work. We thank our collaborators in RIBBiTR and the Jenkinson lab for their research to support frog conservation and improve understanding of amphibian resilience to disease.

PC: Juyung Yoo