Using Natural History to Unlock the Past for the Future of Ecological Inquiry

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One reason why natural history is so important now is that we do not know what questions we will need to ask in the future. Natural history collections and field notes can be extraordinary storehouses of information if we curate them well and handle them with the care and protection we would give ancient artifacts or works of art.

More than a decade ago, I relocated to southern California and took a position at a public wildlife agency, where I was tasked with managing an endangered salamander species. As a result, I soon metamorphosed from a bird and mammal field biologist to a mud-covered, wader-clad, nocturnal herpetologist. Naturalist that I was, I quickly learned the local amphibian community assemblage, and came to know individual species in that familiar way that lends a sense of place and homecoming, just as learning to identify birds in different regions of North America had in the earliest stages of my career.

After two years of southern California residency, I was sure I knew the amphibian diversity and natural history of the region; however, I was stunned to learn that (1) there was a frog species missing from the stream-dwelling amphibian assemblage, (2) this species disappeared suddenly and had been missing for four decades, and (3) nobody knew why. The mystery soon became the motivating force behind the questions that drove my dissertation research for the next six and a half years.

The foothill yellow-legged frog (*Rana boylii*) went extinct in southern California sometime in the early 1970s (Jennings and Hayes 1994). As far as localized amphibian extinctions go, that is breakneck speed. Of the many threats to amphibians, only one is known to cause such rapid extirpations in the absence of habitat loss, and that is chytridiomycosis—caused by the fungal pathogen *Batrachochytrium dendrobatidis* (Bd; Berger et al. 1998; Lips et al. 2006, Gillespie et al. 2015).

I wanted to know—could chytridiomycosis have caused the rapid extirpation of *Rana boylii* from southern California? If it was Bd that caused *Rana boylii* to disappear, we might be able to reintroduce them to areas that are in a post-epizootic (i.e., enzootic) state.

However, understanding whether Bd caused the extirpation in the first place is an essential prerequisite to successful reintroduction planning. What caused the original extinction is just one of the many questions we should ask before carrying out reintroductions (IUCN/SSC 2013). But how can we begin to answer these questions if the species is no longer there for us to study?

Inside jars of formalin-fixed frogs and fumigated feathers is a storehouse of information ecologists need in order to answer important questions about phenomena that are no longer directly observable due to the passage of time. Natural history collections, field notes, and even memories hold data that can give us a glimpse into a different time in which now-extirpated organisms lived, and combining natural history collections with local ecological knowledge can open up powerful avenues of ecological inquiry (Golden et al. 2014).

Natural history information from museums, field notes, and conversations with senior naturalists provided the means to address the *Rana boylii* mystery. I sampled over 1500 museum specimens from before, during, and after *Rana boylii*'s decline to see when in time I could detect the pathogen. Using quantitative polymerase chain reaction (qPCR; Adams et al. 2015), I was able to detect Bd DNA in the museum specimens to examine the number of infected individuals through time.

I also conducted interviews with senior herpetologists to confirm their observations of *Rana boylii* in the field before it was extirpated. They told me their stories about looking for frogs in southern California streams and the changes they saw. Many of them took to their garages and attics, dusted off their old field notes, and sent them to me. Synthesizing all of this information, I found that *Rana boylii*'s extirpation coincided with the proliferation of Bd in the region (Adams et al. 2017), suggesting that the pathogen may have played an important role in the frog's disappearance.

Importantly, the interviews made clear that *Rana boylii* disappeared under the radar. Amphibian populations naturally fluctuate (Pechmann et al. 1991), so it was not considered unusual or worrisome when the species was disappearing. One interviewee described observing the declines in real time:

> *"…I would go to places I had seen them and they wouldn't be there anymore… I didn't think anything of it, of course—you see those patterns—but I saw 2 or 3 frogs at a spot one year and then went back 5 years later and didn't see anything. It didn't mean anything [at the time], but when you don't see them any more times that you're out there…then you realize that they're gone."*

At the time that *Rana boylii* was disappearing from southern California, Bd and chytridiomycosis would not be discovered and described for another 30 years (Longcore et al. 1999). Being able to access the past through specimens, field notes, and memories was essential for addressing the mystery of this rapidly disappearing frog because no other information was available.

Joseph Grinnell, legendary naturalist and founding director of the University of California Museum of Vertebrate Zoology, was among the first in the U.S. West to use natural history information to forewarn of the anthropogenic changes taking place in wildlife populations. He had the foresight to begin collecting specimens for scientific purposes in the early 1900s, prior to which there were no systematic efforts to do so. In addition, his emphasis on taking detailed field notes amplified the value of those collections. He wrote,

> *"Many species of vertebrate animals are disappearing; some are gone already. All that the investigator of the future will have, to indicate the nature of such then-extinct species, will be the remains of these species preserved…"* (Grinnell 1922)

Turning to specimen collections for ecological data amplifies existing research infrastructure by making better use of what is already available, while leveraging technology and applying it to collections enables the information to be shared all over the world (Lips 2011). Natural history collections provide long-term ecological datasets in the absence of systematic long-term monitoring programs (Lister and Climate Change Research Group 2011), and they can provide a window into past environmental conditions that inform models of current and future conditions (DuBay et al. 2017).

Just as Grinnell had the foresight to appreciate the value of collections 100 years ago, it is essential that ecologists, naturalists, and citizen scientists work to document and preserve biodiversity for the ecological questions yet to be asked. What can we do to ensure natural history collections are preserved and maintained for ecological inquiries yet to come?

My answer is four-fold. We can *advocate* for natural history collections at local institutions and support them. We can *use* natural history collections for our research and teaching. Natural history collections are an undervalued resource for undergraduate education that allow for direct observation and wonder of the natural world, and digitization of collections have made their use in classrooms more accessible than ever (Cook et al. 2014). We can *practice* natural history, and record biodiversity information—whether with field notes or a smartphone app. We can *share* our knowledge, expertise, and love for nature.

The steps we take today to honor and preserve natural history will serve to address ecological questions we can't yet comprehend; let's preserve the past to provide more hope for a better future.

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