Research Highlights:

- Ranavirus epidemics can cause die-offs in tadpole populations, where >95% of individuals die over the span of a few weeks.
- I observed ranavirus-associated tadpole epidemics at 7 of the 40 ponds I surveyed in 2021, 1 of the 30 ponds I surveyed in 2022, and 4 of 32 ponds I surveyed in 2023.
- There is clear variation in ranavirus epidemic frequency and intensity across ponds and years, suggesting that epidemics are influenced by a combination of factors at a regional, local, and individual level.

Research Summary:
Epidemics do not exclusively impact humans. Outbreaks of infectious diseases can lead to fatal outcomes for a vast array of species, ranging from the smallest microorganisms to the largest mammals. One of the most striking consequences of epidemics is the occurrence of mass mortality events, during which a significant portion of a population succumbs to a disease in a brief time span. These events can have profound effects on populations and ecosystems, yet they are infrequently examined in a systematic manner due to the challenges in forecasting and identifying them. As a result, many critical questions about mass mortality events in various host-pathogen systems remain unanswered. Questions such as the frequency of these events, the environmental factors that exacerbate their severity, and the implications for the populations that endure them are crucial for conservation and management efforts. Therefore, conducting research on animal populations where mass mortality events can be reliably observed across multiple groups can significantly enhance our comprehension of the dynamics of disease-driven mass mortality events.
Research Summary cont.

Wood frogs, a familiar sight in New England, are especially prone to infection with a dangerous virus called ranavirus. This virus is notorious for causing outbreaks that can kill more than 95% of tadpoles in some areas. Despite how serious these outbreaks can be, we don't know as much as we should about these outbreaks because not enough studies have been done in places where the virus causes recurring die-offs. For the last three years, from spring to early summer, I've been visiting over 30 ponds in the Yale-Myers Forest to check on the wood frog tadpoles and see how many of them are getting sick with ranavirus. Each time I go, I collect some tadpoles to find out how much virus they’re carrying and how widespread the infection is. I also take samples of the water to look for DNA from the virus, which helps us understand how much the virus is spreading in the pond. We've found that when there's a lot of this virus DNA in the water, it usually means more tadpoles are getting sick and dying. I also keep an eye on the environmental conditions such as the pond's temperature, how much oxygen is in the water, how salty the pond is (mainly from road runoff), and how many tadpoles there are, since these factors may also affect how bad an outbreak gets.

I observed die-off events at eight ponds surveyed in 2021 and one ranavirus die-off event in 2022. In 2023, I detected four ranavirus die-off events. Across all the ranavirus epidemics observed from 2021-2023, each tadpole die-off was associated with a rapid spike in ranavirus eDNA concentrations and tadpole infection intensity. In contrast, ponds without die-offs tended to contain no/very little detectable ranavirus eDNA and no/very few infected tadpoles. We are beginning to use the data collected from these three years of surveys to piece together infection patterns and mechanisms that may drive these die-offs. For example, we are finding some evidence that some ponds are consistently “sick,” whereas we never detect the virus on other ponds. However, despite some consistencies in where we find infection, there is clear variation in ranavirus epidemic frequency and intensity across ponds and years, suggesting that epidemics are influenced by a combination of regional-, local-, and individual-level factors. Because of this, we are taking a multi-pronged approach to explore the drivers of die-offs. For example, some recent work at other universities suggests that the amphibian microbiome (the complex community of microorganisms, including bacteria, viruses, and fungi that live in/on an organism) may impact and is impacted by ranavirus outbreaks. To help determine what role the microbiome plays in determining die-off severity, we are using DNA sequencing techniques to quantify the bacterial communities in wood frog tadpoles from ponds that experienced die-offs and ponds that did not. With this data, we can begin to address questions such as “Does the tadpole gut microbiome differ across ponds with and without die-offs?” and “How does the tadpole gut microbiome change through time in a population experiencing a die-off?” This data, along with the information on local and regional conditions across 2021-2023, will help us better understand the causes and consequences of these die-off events.

Amphibians are facing a major crisis with over one-third of species around the world at risk of extinction. Ranaviruses may play a role in this problem, causing sudden and severe drops in some amphibian populations. These declines are likely to get worse as the climate changes, altering their environments. By keeping an eye on what causes these die-offs early on, we can get better at predicting and stopping future disease outbreaks in animals at risk. Studying how deadly diseases affect certain amphibians, such as wood frogs, can also help us understand more about how virus outbreaks start and spread in general.