Amphibians and our shared ecosystem

Nicholas I. Hutson ’26

Department of Biology, Hampden-Sydney College, Hampden-Sydney, VA 23943

Introduction

Amphibians are the most endangered Class of animals in the world (1), but also hold a uniquely important niche in the natural world. Amphibians are split into three groups or Orders; Anura (frogs and toads), Gymnophiona (caecilians), and Urodela (salamanders). This article will focus primarily on Urodela and Anura, but the effects the changing environment has had on those orders are not limited to them. These effects are widespread and have had devastating effects for nearly all animals, but especially so for amphibians. In today’s Anthropeoscenic climate, amphibians are approaching a locus of extinction, with a multitude of variables coming together to affect them in unique and often fatal ways.

Amphibians occupy a unique ecological niche, being ectothermic and living partially of their life cycle in water. These factors are extremely dependent on the environment, especially parts of the environment that have changed drastically over the last several decades (temperature, water quality, air quality, etc.). (2,3) This means that amphibians are two very important things: Significant bio-indicators (indicators of environmental health) and Vulnerable (4). So, we can learn a lot about the health of our environment by looking at the health and population numbers of many amphibian species, especially in North America. North America has more species of salamanders than any other continent (5) which gives us a perfect opportunity to view the effects of our changing climate and a possibility to fix it on local levels. In addition to these environmental factors, various diseases have been affecting amphibian populations, creating even larger damage to their already dangerously low population numbers. Furthermore, according to the Global Amphibian Assessment 2, 41% of worldwide amphibians are considered at risk or worse for extinction (6), compared to birds (13%), mammals (27%), and reptiles (21%) with significantly lower rates (but still dangerously high). There are several factors that can cause this, like climate quality or temperature (2,3), and the effects of them are far more than losing some animal variety.

Biodiversity is well known to assist in making an ecosystem more stable and healthier (7), but what does a weakening ecosystem mean? Both for humans and the rest of the natural world, the consequences are nothing to be ignored. Some consequences for the natural world are often well known, being taught in schools or discussed on news networks. Consequences such as species extinction or rising ocean levels. But fewer people know about the severity of these situations or the real tangible effects they have not only on the world but the very soon future for humanity. Approximately 70% of the Cancer treatments come from (or are derived from) natural products (8), and with up to 150 different species going extinct every day (9) we are losing not only possible cancer treatments, but treatments for a variety of ailments. A specific example is the Gastric Brooding frog, which will be explained with more detail later in this article. Every species we lose is not only weakening the biodiversity of the ecosystem it's in (and thus by extension the entire biosphere) but also directly affecting humans as we lose knowledge of potential cures or treatments to past, current, and future conditions.

We are living through a time period where extinction occurs frequently, most often attributed to human action and drastically shifting climate. And amphibians are not only some of the most affected but also one of the first to go extinct. This is due to several factors, arguably the most important part being the shift in the climate and the specific vulnerabilities amphibians have to those shifts.

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“The environment is changing” is an idea that has a lot of associations with it. Some believe that the environment isn’t changing at all (despite data), while others believe that the changes that are occurring are natural and not significantly impacted by human action (still, despite data). But study after study confirms that the climate is changing rapidly (2), and consequences are dire.

The consequences for a changing climate aren’t limited to ruining vacation homes or killing wildlife. The initial impacts (events such as increased hurricanes and severity) are only the beginning (10). As intense storms hit the world more often (this article will focus primarily on the Americas due to high amphibians’ presence) as a result of higher sea temperatures, sea levels, and warming of the tropics (10) we are left to observe the impacts both in terms of wildlife population damage and habitat destruction. Amphibians, located near water, are especially vulnerable. Amphibians near the coast are at risk of complete destruction of their habitat, both from direct and indirect human interference. Direct interference in this case would refer to pollution into the waterways that these animals call home, or simply purposefully destroying the area to build something there (like the Florida wetlands).

Pollution is a very dangerous force against nature. It has so many ways to have an impact, and many more than is commonly thought of. Trash and plastic waste are the most commonly taught about forms of pollution and what's easiest to see from a human perspective. Driving on most roads you can often find some kind of trash pollution. And while this kind of pollution is dangerous, it's far from the only kind.

Thermal pollution is occurring both in our waters and in our air (2). By increasing temperatures, several environmental factors can be affected, such as increased risk of natural disaster or shifted animal behavior (11).

Chemical spills from improperly disposed substances often find their way into the ground and water, which can affect all animals, but amphibians are affected both in unique ways and more frequently than most others. In 2021, a phosphate plant in Florida spilled millions of gallons of polluted water into Tampa Bay, causing massive fish kills and an evacuation of nearby human residents (12). This one chemical (Phosphate) was tremendously impactful for this environment. Phospherous (a core atom in phosphate) is often a limiting factor in algae growth, which can cause population booms leading to massive fish kills via eutrophication (essentially removing dissolved oxygen in the water, "drowning" large populations of fishes) (13). This is often termed 'nutrient pollution' as it adds nutrients that can severely unbalance the local ecosystem. Amphibians are impacted by this in similar ways the fish are, as their young (often fully submerged in water like frog tadpoles) are suffocated underwater, or as an adult, the same happens to their food source. But uniquely, with the special traits of amphibians (more details will be discussed in the next section) such as porous skin led to them suffering increased effects.

Amphibians

Amphibians are unique as stated before, they have a variety of traits that make them especially vulnerable to the rapidly shifting climate of today. Key features from the majority of amphibians include: Wet porous skin, relying on water for breeding, they typically eat insects and can have a variety of toxins (14). Each of these adds a level of importance not only to their unique ecological niche that any individual species adds to their environment, but also how they benefit humanity at large.

Porous skin is crucial to the amphibian lifestyle, as this is how they breathe. Amphibians breathe through 'Cutaneous respiration" which works by having a unique vasculature that allows up to 100% of both oxygen and carbon dioxide to be absorbed and expelled through the water on their skin (15) (Some species, like *Plethodontidae*, do not have lungs. Making their skin their main method of respiration (17). This works by oxygen diffusing into the water on their moist skin, while carbon dioxide is expelled in the inverse method (16). This style of breathing is extremely vulnerable to pollution of all types. With increased thermal pollution, water becomes rarer. With chemical pollution, they absorb these chemicals which can cause a variety of effects, especially cancer much like in humans (Egea-Serrano A et al.). With physical trash pollutants such as human waste (plastic bottles, bags, gum, etc.) their skin can become physically blocked, strangling them.

Another important factor in amphibians is their habitat. Most rely on water to bear and raise young. For example, take the American bullfrog (*Lithobates catesbeianus*). The female must lay its eggs in the water, after which they will hatch and become tadpoles (19). If water sources dry up that leaves a large section of their life cycle possibly out of reach. Another important concept for amphibians is that they don't exist in a vacuum, as nothing on our planet does. All things contribute and affect their ecosystem. Frogs are crucial in keeping insect populations down (20) such as crop pests and mosquitoes. Without frogs (and most other amphibians, as insects are a major part of their diets) insect populations would increase. An increase in insect populations would heavily contribute to less food production as crop pests become more prevalent. So, amphibians the world over affect the economy as well as their ecosystem.

Another important fact about amphibians is their benefits to human understanding of medicine and ecology. We can gain greater understanding of how the animal world works (and thus better ways of research and learning) and medicine. Two examples work for this idea, the *Bufonidae* family and the Gastric Brooding Frog. A large number of successful antimicrobial and other beneficial drugs/antibiotics have come from *Bufonidae* (21) which has let us learn how to better treat not only their poisons but also help humans against other forms of toxins. Such as helping us create more and better antibiotics to help with infections. The final example is the Gastric Brooding Frog (*Rheobatrachus*), which went extinct in 2015. This frog was able to completely shut down its stomach and used that to allow it's young to grow and mature until they were old enough to survive on their own (22). Had this organism been studied with today's technology and time, it could have been possible to find enzymes or molecules to assist in curing or treating stomach-related illnesses. But since its extinction, we are set back in our data and forced to find alternatives.

Conclusion

While the environment and the animals that inhabit it are inextricably linked, amphibians share a distinctly close relationship. The environment (especially pollutants) has a powerful effect on them and their populations. Pollutants have the most direct impact, while environmental effects are further reaching and much harder to fix. At the current rate many more animals will go extinct, leaving us with fewer research opportunities and a weaker biosphere. Amphibians are most likely going to be another major clade to go extinct very soon, as it may be impossible to revert the damage done completely in time. But knowing about the issue is critical for any attempt to fix or lessen the impact of any problem. With a better understanding of how the climate and habitat affects amphibians, maybe they can be saved.

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