REPTILES & AMPHIBIANS

The Political Economy of Amphibian Declines

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Abstract.—Recent conservation research stresses the importance of examining economic growth as an underlying driver of biodiversity loss. With exceptions, herpetological research on the causes of amphibian declines, endangerments, and extinction risks tends to focus on proximate rather than underlying drivers. This paper connects proximate causes of amphibian declines to structural attributes of modern societies, specifically a growth-dependent economic system. Amphibian declines caused by habitat modification, climate change, contaminants, and commercial use are all in part driven by "the treadmill of production" — capitalism's systemic need to constantly expand. Recognizing the negative impacts of a growth-dependent economy on amphibians has important implications for conservation strategies.

The problem of declines in amphibian populations across the globe was first recognized during the first World Congress of Herpetology in 1989 (Green et al. 2020). Although the scale and extent of declines took time to systematize (Grant et al. 2020), concern about amphibian declines accelerated soon after, not only because amphibians are the most threatened vertebrate taxa, and thus, "representative" of biodiversity loss as a whole, but also because of (1) the notable uptick in reports of declines and extinctions since the 1980s, (2) the declines and extinctions happening in many different areas in the world, and (3) reports of declines in amphibian populations even in protected areas (Collins and Storfer 2003). Later, two *Science* articles by Barinaga (1990) and Wake (1991) highlighted the problem. Furthermore, research in the late 1990s and early 2000s empirically demonstrated that worldwide amphibian declines were a serious problem (e.g., Green 1997; Alford and Richards 1999; Houlahan et al. 2000; Alford et al. 2001; S.N. Stuart et al. 2004).

While unknowns persist in regard to the exact extent and scale of amphibian declines due to methodological issues, Grant et al. (2020) noted that "declines are real and that they are ongoing and catastrophic in some locations." Among the species examined, the International Union for Conservation of Nature (IUCN) estimated that around 41% of amphibian species are threatened with extinction (Luedtke et al. 2023) (Fig. 1).

Research has identified the leading causes of declining population sizes and increasing extinction risks among amphibian species (Blaustein and Kiesecker 2002; Collins and Storfer 2003; Beebee and Griffiths 2005; Sodhi et al. 2008; Hof et al. 2011; Grant et al. 2020). Collins (2010) helpfully summarized six drivers of amphibian declines that frequently appear in the literature: (1) Commercial use (exploitation/overexploitation); (2) introduced/exotic/invasive species; (3) land-use change (habitat loss/modification); (4) contaminants (pollution); (5) climate change; and (6) infectious disease.

Figure 1. The major threat to Endangered (EN) St. Vincent Frogs (*Pristimantis shrevei*) is habitat loss due to urbanization, development for tourism, and agriculture, compounded by *Batrachochytrium dendrobatidis* (*Bd*) and competition with invasive Lesser Antillean Frogs (*Eleutherodactylus johnstonei*) (IUCN SSC Amphibian Specialist Group 2021). Photograph by Robert Powell.

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Some scholars have emphasized the context-dependency of drivers of declines and interrelated causal pathways (Blaustein and Kiesecker 2002; Grant et al. 2020). For example, climate change impacts amphibians differently based on taxon and region (Grant et al. 2020) and climate change, pollutants, habitat changes, and invasive species all mediate the spread and impact of pathogens (Hayes et al. 2010).

Commercial use, invasive species, habitat modification, contaminants, climate change, and diseases are all proximate causes of amphibian declines in the sense that these causes themselves require further explanation. Understanding proximate causes of ecological problems as well as the deeper, underlying causes is crucial. For example, as well as acknowledging the burning of fossil fuels as the primary proximate cause of climate change, examining the underlying drivers of fossil fuel use is equally important (e.g., Clark and York 2005). Recent conservation research stressed the importance of examining economic growth as an underlying driver of biodiversity loss (e.g., Otero et al. 2020; Moranta et al. 2022). We herein seek to bring this insight to bear on explanations for amphibian declines through a conceptual and qualitative analysis that not only draws attention to how the proximate causes of amphibian declines are driven by unchecked economic growth, but also how economic growth is built into the very social structure of modern societies. To our knowledge, previous research on amphibian declines and extinction risks has not explicitly made these connections between proximate causes, which are stressed in most literature on the topic, and underlying drivers, which often go unexamined.

Although the number of underlying drivers of amphibian declines might equal the number of proximate causes (e.g., governance models), we focus on one underlying cause, economic growth driven by a growth-dependent economy, that, following previous empirical research reviewed below, has been proven to have significant explanatory power.

We first summarize the concept of "the treadmill of production" as a primary driver of ecological problems and review previous research that examines animal species declines from this perspective. Of the six major proximate causes, we focus on four: habitat loss, climate change, contaminants, and commercial use. Due to their interrelated role in amphibian declines, we also discuss infectious diseases, focusing on chytrid fungi, in the sections on climate change and commercial use, and touch on invasive species in the section on commercial use. We conclude with a discussion of how attention to underlying social causes can inform conservation efforts.

Treadmill of Production (ToP): Animal Species Declines and Extinction Threats

A growing chorus of literature argues that continual economic growth is inherently unsustainable and that the built-in expansionary mechanisms of capitalism make hopes for a sustainable version unlikely (e.g., Foster et al. 2010; Wright and Nyberg 2014; Hickel 2020; D. Stuart et al. 2020a). A helpful analogy to conceptualize the relationship between economic growth's impact on the environment is the treadmill of production (ToP) model (Schnaiberg 1980; Gould et al. 2004, 2015). The ToP model argues that capitalist economies, due to competition between firms and other mechanisms, must increase and expand production, creating a production cycle (the treadmill metaphor) that necessarily increases natural resource use ("withdrawals") and damaging inputs to the environment, from toxic chemicals to greenhouse gas emissions ("additions"). The treadmill must grow in intensity and size because competing firms must reinvest profits in production to expand and further maximize profits. The state is generally complicit with the goal of growth above all else, often making political decisions favorable to economic expansion even if the latter negatively impacts the environment (Schnaiberg et al. 2002).

Although other drivers of environmental harm exist, the ToP is systemically linked to some of these drivers. For example, consumerism and overconsumption often are blamed for increasing environmental harm, but consumerism is a necessary extension of the treadmill and is actively encouraged by expanding firms via aggressive advertising and marketing (Schnaiberg 1980; D. Stuart et al. 2020c). Research has shown that economic growth is a major driver of global environmental problems, such as climate change (e.g., Schor and Jorgenson 2019; Hickel and Kallis 2020), and, importantly here, biodiversity loss and species declines and endangerment (e.g., Foster et al. 2010; Czech et al. 2012; Otero et al. 2020; D. Stuart et al. 2020b; Moranta et al. 2022).

The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES 2019) concluded that humans are driving global changes in plant and animal life that are unprecedented in history. With amphibians as a central illustration (Wake and Vredenburg 2008), this often is referred to as the sixth global mass extinction event and, by some as the "extinction tsunami" (Lovejoy 2017) or "biological annihilation" (Ceballos et al. 2017). Many scholars have argued that the biodiversity crisis is caused by economic growth or, more specifically, the growth-dependent system of capitalism (e.g., Foster et al. 2010; Czech et al. 2012; Lynch et al. 2015, 2019; Otero et al. 2020; D. Stuart et al. 2020b; Moranta et al. 2022). Previous research has applied the ToP model and related frameworks to examine the political-economic drivers of animal species declines and extinction risks (Czech 2000; Naidoo and Adamowicz 2001; Hoffmann 2004; Clausen and York 2008; Czech et al. 2012; Lynch et al. 2015, 2019; Sol 2019; D. Stuart and Gunderson 2020; Pouteau et al. 2022). GDP growth often is found to be associated with species declines, including amphibians, and biodiversity loss in general (e.g., Naidoo and Adamowicz; Sol

2019; Habibullah et al. 2022; Pouteau et al. 2022). IPBES (2019) stated that a key component of sustainable pathways is the evolution of global financial and economic systems to build a global sustainable economy, steering away from the current, limited paradigm of economic growth. We agree with these previous scholars that examining the structural causes of ecological changes that impact species declines and extinction risks is important. Our goal is to draw attention to some of the processes through which the ToP drives the proximate causes of amphibian declines. Because we examine the connection between proximate causes and underlying drivers in general, reiterating that the impact of each cause can vary by region and taxon is important (see above).

ToP, Habitat Loss, and Amphibian Declines

The Environmental Kuznets Curve (EKC) hypothesizes that development (increased economic activity) initially leads to environmental degradation, followed by environmental protection as per capita income increases and affords attention toward conservation. Increasing evidence counters this narrative (Dietz and Adger 2003; Tevie et al. 2011). Dietz and Adger (2003) showed that evidence does not support the EKC, concluding that economic growth leads to habitat loss and declines in biodiversity. In their analysis, they drew on scholars who have examined deforestation and found little to no support for EKC (e.g., Shafik 1994), further indicating a link between economic growth and habitat loss (cf. Mills and Waite 2009). Localized studies also have demonstrated the link between economic growth and habitat loss, especially due to urbanization. For example, habitat loss driven by economic growth in Japan has endangered an endemic eel due to urbanization (J.Z. Chen et al. 2014) and increasing land values in Panama drive economic growth and development, and, with them, associated land modification and loss, removing habitat for species (Rompre et al. 2008). Increasing per capita GDP in the United States is closely associated with habitat loss and species declines (Czech et al. 2000, 2012), consistently undermining arguments for the EKC and instead providing further evidence linking economic growth, habitat loss, and species declines (Tevie et al. 2011). At a global level, Weinzettel et al. (2013) demonstrated that affluence leads to increased per capita demand for productive land, but that rich countries draw this from less developed countries, effectively exporting habitat loss.

Economic growth-induced habitat modification has direct consequences for amphibians. Green et al. (2020: 99) stated that habitat modification "emerges consistently as the primary, and often sole, source of threat to amphibian populations" (Fig. 2). Many amphibians require specific habitats or are endemic and cannot survive in highly altered habitat conditions (Roach et al. 2020). Specific habitat modification via land changes, including dam construction that floods amphibian habitat (Dare et al. 2020), wetland loss that causes disease and diminishes habitat connectivity (Buck et al. 2012), land conversion for food production (Dudley and Alexander 2017), and urbanization (Hamer and McDonnell 2008), adversely impact amphibian species and populations. Habitat loss and fragmentation (e.g., via road networks and infrastructure) cause many negative impacts, including decreased connectivity, habitation isolation, and limited dispersal, creating increased amphibian vulnerability and declines (Cushman 2006; Pinto et al. 2023). Forests remain essential for amphibian species, including rare species found predominantly in interior forest habitats (Schneider-Maunoury et al. 2016). Forest conversion decreases habitat and fragments existing forest patches, leading to changes in humidity, temperature, and other factors that affect amphibians (Schneider-Maunoury et al. 2016). Mounting evidence shows a clear linkage between habitat loss and amphibian declines (Sodhi et al. 2008).

Habitat loss has continued despite warnings. Narrow explanations, especially regarding human population growth as a primary driver (Cafaro et al. 2022), have received strong critiques (Hughes et al. 2023) and highlight the need to uncover the underlying forces responsible for habitat loss and species declines, notably the ToP driving economic growth. As explained above, economic growth does not occur in a vacuum — it is propelled by the structural need to increase and reinvest profits. That is why many scholars point to capitalist processes as the fuel for the endless economic expansion that destroys habitats (e.g., Barbosa 2009; Lynch et al. 2016; Smith et al. 2020). For example, Sri Lanka has the highest

Figure 2. The principal threat to Critically Endangered (CR) Axolotls (*Ambystoma mexicanum*) is the desiccation and pollution of their habitat in the canal system and lakes in Xochimilco and Chalco of the Mexican Central Valley, as a result of urbanization and increased tourist activity (Zambrano et al. 2009), especially now that all animals in the international pet trade are thought to be captive bred (IUCN SSC Amphibian Specialist Group 2020). This individual is in an aquarium in Xochimilco Ecological Park in Mexico City. Photograph by Marco Ugarte.

number of recorded amphibian extinctions, with the primary proximate cause likely being deforestation (Meegaskumbura et al. 2002; Re:wild et al. 2023). Of 18 extinct frogs recognized by the IUCN, 11 species were last recorded prior to and during the 1880s (Re:wild et al. 2023). Mass deforestation of the Sri Lankan highlands' montane and sub-montane forests to establish coffee plantations from around 1830 to 1880 followed land privatization measures introduced by British colonists (Wickramagamage 1998). From 1881 to 1956, a period in which Sri Lankan land continued to be commodified into tea and other plantations under British rule until 1948 (Bandarage 2023), closed-canopy forest cover plummeted from 84% of the island to 44% (Bandaratillake 2001). This planation phase of colonization was powered by forces that still hold Sri Lanka, and most of the rest of the world, in their grip: profit-seeking, commodification, and capital accumulation (Wickramasinghe and Cameron 2004; Bandarage, 2023)[1]. More generally, Lynch et al. (2019: 97) discussed the relationships between the ToP, habitat loss, and species declines as follows: under ToP conditions, "the availability of resources for species consumption declines. This includes ecological resources related to nonhuman animal habitat. In that context, nonhuman ecological habitat shrinks and becomes segmented, impeding the ability of nonhuman species to maintain their population base." Habitat loss happens for many reasons, including conversion from forest and other ecological systems to agriculture, clearly pointing to proximate causes for amphibian declines. These explanations should also seek to identify the root causes leading to species declines. A ToP perspective can help fully explain and contextualize the role of habitat loss in amphibian declines.

ToP, Climate Change, and Amphibian Declines

Climate change is increasingly implicated as a potential driver of amphibian declines; consequently, examining the structural drivers of climate change itself is critical. For some time we have known that economic growth is a major driver of greenhouse gas emissions (e.g., York et al. 2003; Stern 2006; Jorgenson and Clark 2012), with a 1% increase in GDP associated with a 0.5–0.7% increase in carbon emissions (Burke et al. 2015). Further, the most notable reductions in emissions are caused by economic recessions due to reductions in production and consumption (Feng et al. 2015). To draw attention to the necessity of transforming the economic system in fundamental ways, scientists continue to illustrate positive linkages between economic growth, energy consumption, and carbon emissions (e.g., H. Chen et al. 2022). While some studies point to the possibilities of "decoupling" carbon emissions from economic growth (Hubacek et al. 2021), decoupling, to stay within global emissions reductions goals, would need to be: (1) absolute, (2) global, and (3) permanent. According to recent analyses, decoupling in these terms has not occurred and is very unlikely to occur (Parrique et al. 2019; Hickel and Kallis 2020; Vaden et al. 2020). Economic growth is a major driver of climate change that likely cannot be decoupled from emissions at the scale and rate needed to avoid catastrophic climate change. The current economic system requires constant economic growth, which is a major driver of greenhouse gas emissions (D. Stuart et al. 2020a).

The fact that a growth-dependent economic system drives climate change is of utmost importance for understanding amphibian declines. Climate change, coupled with habitat loss and modification (see above), poses a significant threat to amphibians (Nowakowski et al. 2017). At least five variables affected by climate change impact amphibian populations: maximum summer temperature, winter severity, soil moisture, water availability when breeding, and snow-water equivalent (Miller et al. 2018; Grant et al. 2020). As mentioned previously, the impact of climate change on amphibian populations depends on taxon and region. For example, climate change can create new habitats for some amphibian populations through the melting of ice (Seimon et al. 2007) or increase breeding rates in some species due to less severe winters (McCaffery and Maxell 2010). However, climate change is generally discussed as a net harm for amphibian populations (e.g., Collins 2010; Luedtke et al. 2023; Bickford et al. 2024). For example, climate change likely contributes to amphibian declines in Costa Rica due to microhabitat loss (Whitfield et al. 2007), in Yellowstone National Park due to wetland desiccation (McMenamin et al. 2008), and in parts of the southwestern United States and the southern Mississippi Delta due to changes in precipitation patterns (Grant et al. 2020). Further, from 2004 to 2022, climate change was the primary driver behind amphibian species that were assigned to more threatened categories in the IUCN Red List (e.g., moved from "near threatened" to "vulnerable") (Luedtke et al. 2023). Although more research is needed to address uncertainties, "many amphibians might have reached or exceeded most limits in their ability to adapt or tolerate further climate change" (Bickford et al. 2024).

Climate change can also be linked to the spread and outcomes of the amphibian chytrid fungus, *Batrachochytrium dendrobatidis* (*Bd*), which disrupts the ability to respire and osmoregulate through skin, killing the given amphibian if heavily infected (e.g., Rohr and Raffel 2010; Cohen et al. 2017, 2019; Rollins-Smith 2020). Both *Bd* and *Batrachochytrium salamandrivorans* (*Bsal*) cause chytridiomycosis (Fisher and Garner 2020; Rollins-Smith 2020), contributing to population declines in over 500 amphibian

[1] This is not to assert that these extinctions necessarily occurred during British rule (the exact timelines of extinction are unknown), but, instead, to point out that the underlying structures behind mass deforestation were installed during the colonial period.

species (6.5% of described amphibian species) (Fig. 3), 90 of which are presumed to be extinct (Scheele et al. 2019). Links between chytrid fungi and climate change are contested and still being investigated and debated (Carey and Alexander 2003; Rohr et al. 2008; Collins 2010; Cohen et al. 2017, 2019; Rollins-Smith 2020). A recent hypothesis, termed "the thermal mismatch hypothesis" (Cohen et al. 2017), predicts that "amphibians from cooler environments are more vulnerable to mortality from chytridiomycosis under warmer conditions than those from warmer environments," a hypothesis supported by experimental and field-data (Cohen et al. 2019). In a review of the role of chytrid fungi in global amphibian declines, Fisher and Garner (2020) explained that multiple pathways through which ecological changes influence disease outcomes, including climate and UV-exposure. Climate change can also impact the disease outcomes of other amphibian-killing pathogens. For example, climate-related changes in water depth in the Oregon Cascade Mountains led to higher embryonic deaths due to higher UV-B radiation exposure, increasing vulnerability to infection by the water mold *Saprolegnia ferax* (Kiesecker 2001). More research is required to better understand possible links between climate change and disease outcomes among amphibians (Rollins-Smith 2020).

To summarize, the ToP requires continual economic growth, economic growth is a major driver of climate change via greenhouse gas emissions, and climate change likely plays a major role in amphibian declines. Despite these connections, outside of the critical literature reviewed above, we were unable to find discussions of economic growth and capitalism in the herpetological and conservation literature addressing the relationships between climate change and amphibian declines. A similar gap in the literature exists regarding relationships between contaminants and amphibian declines.

Figure 3. Illustrated here is a Critically Endangered (CR) Panamanian Golden Frog (*Atelopus zeteki*), for which *Batrachochytrium dendrobatidis* (*Bd*) has been identified as the major threat (IUCN SSC Amphibian Specialist Group 2019). Photograph by Brian Gratwicke, Smithsonian's National Zoo and Conservation Biology Institute.

ToP, Contaminants, and Amphibian Declines

Although a number of contaminants have been examined as potentially contributing to or causing amphibian declines (e.g., Sparling 2003; Hamer et al. 2004), we focus here on pesticides, the most commonly discussed contaminant (Boone and Bridges 2003). Economic growth is correlated with increasing rates of pesticide use. Pesticide-use intensity increases with national agricultural exports, which are components of total GDP (Longo and York 2008), and foreign investments in agricultural sectors have a positive effect on pesticide-use intensity (Jorgenson and Kuykendall 2008). More recently, Hedlund et al. (2020) analyzed data from the United Nations and World Bank finding that "the relationship between economic growth and environmental impacts, operationalized as use of chemical pesticides, is significant, positive, and increasing faster than population growth" (p. 538) and that "[g]rowth in economic development tends to increase the consumption of agrichemicals that have serious potential consequences for human health and the broader environment, even when controlling for the size of the agricultural economy of a nation" (p. 542). Global pesticide use has increased approximately 50% since 1990 with 2.7 million tons applied in 2020 (FAO 2022).

Pesticides used in agricultural landscapes migrate in the environment through volatilization, spray drift, leaching, sorption (binding to soil particles), and surface runoff, and therefore reach a wide range of non-target organisms that can be harmed through direct contact or delayed effects (Tudi et al. 2021). Pesticides are especially damaging to aquatic ecosystems and organisms, including amphibians. A recent study on frogs illustrated how amphibians in protected areas far removed from agricultural practices have been found to be exposed to similar levels of pesticides as those near agricultural areas (Brodeur et al. 2022).

Pesticides in surface waters are the primary route of exposure for amphibian species. Exposure to the common herbicide glyphosate increases mortality in tadpoles and juvenile frogs (Relyea 2005). Mimicking the "real world" outdoor environmental exposure associated with agriculture in South America, Agostini et al. (2020) found that amphibian survival decreased in 13 of 20 applications of pesticides at levels commonly detected in ponds. Organisms also are commonly exposed to more than one pesticide. Frogs in agricultural regions, for example, are exposed to pesticide mixtures that are likely responsible for population-level effects (Brodeur et al. 2022). In addition, chemical exposure combined with disease can increase mortality rates (Pochini and Hoverman 2017). For example, Cusaac et al. (2021) studied subadult Eastern Hellbenders (*Cryptobranchus a. alleganiensis*) (Fig. 4) and

Figure 4. Illustrating a synergistic effect of diseases and contaminants, exposure to the Frog Virus 3-like *Ranavirus* (RV) and the herbicide Roundup (glyphosate) resulted in 100% mortality in subadult Eastern Hellbenders (*Cryptobranchus a. alleganiensis*) versus 80% mortality with RV exposure alone (Cusaac et al. 2021). Photograph by Brian T. Miller.

found that exposure to the Frog Virus 3-like *Ranavirus* (RV) and the herbicide Roundup (glyphosate) resulted in 100% mortality versus 80% mortality with RV exposure alone.

In addition to increasing mortality, pesticides have been found to negatively affect amphibian reproduction (Mahmood et al. 2016). For example, Karlsson et al. (2021) found that male frogs exposed to pesticides had male offspring with decreased fertility and symptoms of endocrine disruption, and Adams et al. (2021: 213) found reduced feralization rates in frogs after pesticide exposure that resulted in fewer tadpoles, concluding that "[i]n combination with acute toxicity effects, the detected sublethal effects, which are mostly not addressed in the ecological risk assessment of pesticides, pose a serious threat on amphibian populations in agricultural landscapes."

In short, a constantly growing industrial-agricultural system requires continual pesticide inputs, which harm many amphibian species through multiple pathways. Understanding this social context is essential for addressing the contaminants that contribute to amphibian declines.

ToP and the Commercial Use of Amphibians

Environmental social scientists have examined animal agriculture and aquaculture in light of the ToP model and related theories (e.g., Gunderson 2013; Longo et al. 2015). While previous societies have used animals primarily for food and fiber at the personal, familial, and local levels, with some larger markets, capitalism is a unique system that universalizes the commodification of animals for the peculiar purpose of making a profit (Gunderson 2013; D. Stuart and Gunderson 2020). Capitalism also is unique because it structurally necessitates competition between firms and individuals who produce and sell animals for a profit, requiring increases in "efficiency" that can result in increases in ecological degradation and the genesis and spread of pathogens (D. Stuart and Gunderson 2020).

The widespread commodification of animals and structural drive to expand the production and trade of commodified animals have important implications for understanding amphibian declines. Commercial use, also termed exploitation or overexploitation, has been identified as a driver of amphibian declines (Jensen and Camp 2003; Beebee and Griffiths 2005; Collins 2010). Amphibians are primarily commodified for food (e.g., froglegs, bullfrog meat), but also for pet, educational, medical, and fashion markets (Jensen and Camp 2003; Beebee and Griffiths 2005). Most amphibians are collected in the wild, as opposed to captivity, often illegally (Beebee and Griffiths 2005). The commodification and trade of amphibians is global in scale (Fisher and Garner 2007). Due to missing data, estimating how many amphibians are annually traded is difficult (Schlaepfer et al. 2005), but markets can be massive, with, for example, almost 28 million live American Bullfrogs (*Lithobates catesbeianus*; Fig. 5) — the species that has most frequently been implicated in the spread of *Bd* (Kolby et al. 2014) — imported into Los Angeles, San Francisco, and New York in a six-year period (Schloegel et al. 2009). Such markets also are largely underregulated, including those dealing in threatened amphibian species (Hughes et al. 2021; Auliya et al. 2016). Global trade in endangered amphibian species has substantially increased since 1980 (Greenberg and Palen 2019).

The commercial use of amphibians has become a likely contributor to population declines of some species (S.N. Stuart et al. 2004; B.L. Stuart et al. 2006; Fisher and Garner 2007). Perhaps even more concerning is the relationship between commercial use and amphibian declines due to pathogen spread, especially *Bd* (see above) (Fisher and Garner

Figure 5. An American Bullfrog (*Lithobates catesbeianus*) farm in Brazil; note the high densities at which the frogs are stocked. Such markets are known to serve as reservoirs facilitating the spread of *Batrachochytrium dendrobatidis* (*Bd*) in Brazil (Schloegel et al. 2009), illustrating the synergistic effects of invasive species and diseases. Photograph by Lisa Schloegel.

2007; Collins 2010). *Bd* spreads via the global amphibian trade through at least three pathways: (1) transporting infected animals to new locations, (2) the introduction of infected amphibians into naïve amphibian populations, and (3) zoospores in water supplies in co-housed conditions (Fisher and Garner 2007). *Bd* has been shown to spread through Tiger Salamander (*Ambystoma tigrinum*) fish-bait markets (Picco and Collins 2008), American Bullfrog markets (Schloegel et al. 2009), and numerous other frog and salamander markets (Daszak et al. 2004; Fisher and Garner 2007). The prevalence of infection in these markets can be high. For example, samples from 28 million imported American Bullfrogs found 62% infected with *Bd* (Schloegel et al. 2009). In addition to *Bd*, the commercial trade of amphibians also is linked to the spread of other pathogens that negatively impact amphibians, such as *Ranavirus* (Schloegel et al. 2009) and *Bsal* (Martel et al. 2014). Evidence also indicates that pathogens among captive amphibians have spread to wild populations (Gratwicke et al. 2010; Schloegel et al. 2010).

Along with the spread of pathogens, the global amphibian market for commercial use also is implicated in introducing invasive amphibian species that harm native populations (Borzée et al. 2020; Falaschi et al. 2020; Hughes et al. 2021). Invasive amphibian species can negatively impact native populations and reduce amphibian diversity through a number of processes, including competition, hybridization, predation, and the spread of diseases (Falaschi et al. 2020). For example, the introduction of the American Bullfrog through commercial trade in South Korea led to feral populations that altered native amphibian communities and are associated with declines in treefrog populations, primarily via the spread of *Bd* (Borzée et al. 2017). Commercial trade of the African Clawed Frog (*Xenopus laevis*), a species that has been shown to negatively affect native amphibian species, in medical, scientific, and pet markets has resulted in invasive populations in many ecosystems across four continents (e.g., Lillo et al. 2011; for a political-economic history, see Lynn 2021).

We ask herpetologists and conservation biologists to reflect on the following important, if loaded, counterfactual question: Would amphibian-harming pathogens and invasive species spread at the rate and massive scale that they do if it were not for the growth-dependent engine of capitalism that must constantly expand, often through creation of global markets? This question is important because capitalism has become so ubiquitous and familiar that it is typically taken for granted, a “social gravity” that can become invisible to scientists despite having what could be a central impact on the focus of their scientific concerns (York and Clark 2006). Indeed, the goal of this paper is to encourage herpetologists and conservation biologists to direct their attention to this growth-dependent economic system, which has important consequences for conservation efforts.

Conclusion: Implications for Amphibian Conservation

Recent conservation research stresses the importance of examining economic growth as an underlying driver of biodiversity loss. With exceptions, herpetological research on the causes of amphibian declines tends to focus on proximate rather than underlying drivers. The goal of this analysis is to encourage herpetologists and conservation biologists to consistently connect proximate causes of amphibian declines to underlying structural attributes of modern societies, specifically the growth-dependent economic system. Amphibian declines, threats, and extinctions caused by habitat modification, climate change, contaminants, and commercial use are all in part driven by the ToP (i.e., capitalism’s systemic need to constantly expand).

Recognizing the impact of capitalism and economic growth on biodiversity loss has important implications for conservation strategies (cf. Otero et al. 2020; Moranta et al. 2022). Successful amphibian conservation requires challenging the ToP. Amphibian conservation biologists and groups should consider supplementing local and context-specific amphibian conservation programs with policies that increase ecological wellbeing by taming the economic growth imperative. While some of these policies are clearly related (e.g., heavily regulating or banning amphibian markets, opposing growth-strategies that harm amphibian habitats), others are seemingly unrelated to amphibian conservation. For example, as explained previously, economic growth is a major driver of climate change, and climate change has a negative impact on many amphibian populations. Thus, policies and political programs that have been shown to reduce greenhouse gas emissions and increase social and ecological wellbeing, such as worktime reduction (Gunderson 2019), should be advocated by amphibian conservationists. While saying that advertising restrictions and a shorter workweek, for example, are important for amphibian conservation might appear abstract, these are the kinds of systemic connections that this discussion hopes to foster.

Future research should examine more social and political-economic drivers of amphibian declines. Herein we focused on the issue of growth-dependency because we think it is the most significant driver of the ecological crisis. More broadly, we hope that this analysis inspires herpetologists and conservation biologists to explore the political-economic and sociological literature on biodiversity loss and related issues. Social and political variables should be seen as integral, rather than peripheral, to understanding amphibian declines, threats, and extinctions, and implementing successful conservation programs.

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