Elevating human dimensions of amphibian and reptile conservation, a USA perspective

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Abstract
Increasing threats to amphibian and reptile species raise the urgency of their conservation. However, relative to other vertebrate groups at risk, amphibians and reptiles have low and more variable social capital; they are not generally high-priority natural goods and services valued by people. Consequently, relative to other groups such as birds, mammals, and economically important fish, they garner fewer conservation resources. With increasing risks, their situation degrades. We examine five societal sectors with herpetofaunal conservation interests in the United States (local communities, people in defined geographies and jurisdictions, species and threat specialists and advocates, associated researchers, managers, and policy makers) to understand challenges of low and variable social capital for herpetofauna. With current trends of US public values changing from traditionalist consumerism of wildlife to mutualist coexistence philosophies, a refocus of outreach and inreach efforts could help reframe priorities toward species at greatest risk, rather than broad taxonomic biases. Integrated teams of engaged natural resource managers, researchers, and the interested public can help promote species- and issue-based programs to forestall losses, hence programmatically raising social capital. Heightened recognition of the importance of human relationships and herpetofaunal diversity among researchers, managers, policy makers, educators, artists, authors, citizens, and children could provide inertia to reframe conservation program effectiveness at local-to-national scales.

KEYWORDS
ecosystem services, herpetofauna, partnerships, social capital, social networks, threats, values

1 | INTRODUCTION

The Anthropocene era is defined by an approximate threshold in which humans and their activities became integral to myriad global processes and phenomena, including climate change, degradation of ecosystems, and massive loss of biodiversity (Tsing et al., 2020). Although extinctions are documented across taxa, amphibian losses continue to outpace other groups (Stuart et al., 2004; Wake and Vredenburg, 2008). Among vertebrates, 41% of...
amphibian species are estimated to be threatened with extinction compared to 30% of freshwater fishes, 26% of mammals, and 14% of birds (International Union for the Conservation of Nature, 2021a, 2021b). About half of reptile species have had status assessments and of these, about 34% are considered at risk of extinction (International Union for the Conservation of Nature [IUCN], 2021c). Taxonomic biases in global status assessments, however, are widely recognized, precluding a full understanding of risk across taxa (Tingley et al., 2016), often due to data deficiency. Contributing factors to global amphibian and reptile declines have ties to the Anthropocene, including habitat loss and change, human-mediated disease and invasive species transmission, climate change factors, and overexploitation (Böhm et al., 2013; Grant et al., 2020; Stanford et al., 2020). Also due to habitat degradation and overuse, freshwater habitats are among the most-threatened ecosystems (IUCN, 2021c; Penaluna et al., 2017). The human footprint is directly linked to freshwater habitat changes (Su et al., 2021) resulting in broadscale biodiversity losses, including many amphibians and reptiles, collectively known as “herpetofauna.”

Biodiversity conservation iteratively adapts to new knowledge and socioeconomic values. Momentum and fluxes in conservation interests and actions occur over time as species rarity concerns are elevated, new threats emerge, mitigations are tested, or the context of biodiversity conservation is reframed. Fresh approaches to complex biodiversity conservation issues are often needed to address societal fatigue of so many threatened species. In particular, creative, synthetic problem solving is increasingly urgent, given the rising number of at-risk herpetofauna. Integrating innovative efforts is paramount for species conservation effectiveness (Meredith et al., 2016; Sutherland et al., 2021). The crucial role of people and their attitudes in this process, including for often-overlooked taxa like most herpetofauna, has been articulated for decades (Gibbons, 1988) and warrants greater emphasis now.

Herein, we reframe amphibian and reptile conservation from the perspective of interwoven human value and decision systems, with a focus on the United States. We offer an optimistic, but realistic, view that reversing the tide of biodiversity losses depends upon socioeconomic values and capacity to care for species and implement actions for species sustainability, while also addressing urgent priorities of human welfare. An incomplete understanding of exactly how to conserve declining populations or species at risk can stall progress in spite of an urgency to “do something” before it is too late. Hence, application of adaptive learning to hone effective species conservation approaches is crucial. The United States may be poised to advance these conservation approaches today because it (1) has a growing conservation ethos and aestheticism for natural systems and their species components; (2) has economic capacities to apply to priority species and ecosystems at risk; (3) generally applies an interactive research-and-monitoring framework to advance new knowledge for species conservation, with the most recent unbiased scientific evidence compiled to inform priority species-management decisions and policies; and (4) has multiple regulatory authorities with oversight of different aspects of species sustainability, providing a system of checks and balances for biodiversity protections at state- and US-wide scales (e.g., Organ, 2018; Organ et al., 2012). US science and management coproduction of species threat-based research is critical for obtaining the information needed for the development of conservation actions to forestall losses for at-risk species (e.g., for amphibians: Gascon et al., 2007; Grant et al., 2019; Olson, Ronnenberg, et al., 2021). Science-management coproduction toward effective conservation mitigations requires investment, but also a willingness to engage (Beier et al., 2017). Increased attention for this component relative to amphibian and reptile conservation is at a pivotal moment due to increasing threats and cascading losses in these taxa. Herein, we discuss human value and decision-system reasons for insufficient herpetofaunal conservation investment in the United States and considerations to reverse that pattern with a call to increase engagement across several interacting US societal sectors. At the crux is the need to reverse the pattern of the relatively low social capital of amphibians and reptiles.

## 2 | Social Capital of Herpetofauna

Capital is a term used to describe material goods of value or assets. Social capital extends to shared values of people in a society and the network of relationships enabling societal components and society to thrive. As such, Lin (1999) described social capital as “resources embedded in a social structure which are accessed and/or mobilized in purposive actions.” As an extension to this, social capital can apply to the networks of relationships among people and people's shared values of natural resources (Lin, 1999). Social capital for natural resources also has been described as natural capital, nature's goods, and services (Costanza et al., 1997; van den Bergh, 2001; Vitousek et al., 1997).

Contemporary concepts of social and natural capital tie directly to the central thesis of ecosystem services including biodiversity and its conservation (e.g., Millennium Ecosystem Assessment, 2005; Tsing et al., 2020), where (1) the complex networks of human interactions with the world are a driving force in change across natural systems; (2) such change can be harmful to components of nature perceived...
as both commodities of value (i.e., capital) and commons (Hardin, 1968), belonging to all people; and (3) corresponding incentives emerge to develop purposeful actions for their stewardship into the future. Although social or natural capital for conservation of specific taxonomic groups may be a subset of broader biodiversity or nature conservation concerns, in many cases, social capital for species may be considered independently as an incremental approach to the larger ongoing nature-conservation campaign. With the rising tide of at-risk herpetofauna, mobilization of social capital for those taxa specifically is urgent, especially relative to the need for increased incentives for their stewardship. Social science disciplines more specifically address social capital and include several fields with direct application to the human dimensions of natural resource management, including development of conservation incentives (e.g., Bennett, Roth, Klain, Chan, Christie, et al., 2017; Bennett, Roth, Klain, Chan, Clark, 2017). Herein, we further integrate those contributions as they relate to herpetofaunal sustainability issues that are most often managed by wildlife biologists and managers.

Pretty and Smith (2004) proposed that social capital for biodiversity could be improved by socially embedded, jointly engaged learning. They pointed to evidence that inclusive, connected societal groups and networks were more effective at developing sustainable nature conservation programs. We expand upon this thesis for US herpetofauna, where social capital for species (and their conservation) has a dynamic set of dimensions with multiple feedback loops connecting different societal sectors, such as: (1) specific human communities; (2) people in defined geographies and jurisdictions; (3) specialists and advocates of myriad species groups and their threat factors; (4) associated researchers; and (5) related managers and policy makers (Figure 1). Each of these five sectors has a constituency for species conservation, with a component for herpetofauna. Social networks among these five sectors can be complex, comprised of different groups of people engaging with these topics simultaneously or over different time periods. Hence, we depict multiple threads of connections among these five sectors to convey tandem or sequential efforts among sectors (Figure 1). Continuous threads flowing across these sectors may also convey adaptive processes among social networks over time. A first step in using this conceptual framework to address herpetofaunal conservation is to understand sector variance in herpetofaunal social capital and stewardship, then advance understanding of the interactions among sectors (see Section 2.1, in the following). These findings can then be woven into strategies to engage socially embedded, adaptive learning (Pretty & Smith, 2004) within and among sectors for improved herpetofaunal conservation by raising herpetofaunal social capital and consequently stewardship incentives and investments (see Section 3, in the following).

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2.1 Variable herpetofaunal valuation and stewardship investments

In the United States, simply put, herpetofauna often lack social capital for conservation. We propose reduced-and-variable social capital for amphibians and reptiles across sociopolitical sectors and their interactions (Figure 1) is having an increasingly adverse effect. In addition, restricted resources for species conservation may be increasingly parsed to higher-valued taxonomic groups, hampering conservation momentum for herpetofauna. This pattern is especially apparent relative to other main vertebrate groups (birds, mammals, and fish) where in the public eye, herpetofauna may be little known, there can be less overall consensus of the importance of amphibian and reptile species, in addition to considerable variation in social capital among herpetofaunal groups. For example, frogs often get more conservation attention (e.g., Amphibian Week: Partners in Amphibian and Reptile Conservation [PARC], 2021a; savethefrogs.com) than salamanders, which may be more easily confused with lizards among naïve public sectors. Similarly, many people have never heard of the third main amphibian group, caecilians (legless amphibians that live in substrates), or the reptile subgroup of legless lizards, and may confuse both with snakes. Many reptiles are underappreciated and some can be viewed with hostility in comparison with amphibians. For example, amphibian decline issues have attracted considerable attention over the last 30 years (Angelini et al., 2020), whereas similar attention has not been afforded to most reptile groups (Roll et al., 2017). Lack of knowledge of reptiles may be a root cause of lack of conservation attention; data deficiency in reptile species status reviews has been a past gap that current assessment efforts...
are striving to rectify (IUCN, 2021c). Social capital for herpetofauna in these regards relates to both personal values and motivations for long-term species stewardship investments and practices, with considerable heterogeneity in valuation among the five societal sectors that we have defined (Figure 1).

The human valuation of species is a complex social construct of tangible-material and intangible-intrinsic contributions. In an ecosystem services framework where natural resources provide benefits to people, species including herpetofauna may be valued for their tangible roles in provisioning (e.g., material goods such as food, pharmaceuticals, other commodities), regulating (e.g., ecosystem energy transfer and carbon sequestration), and supporting ecosystem services (e.g., central position in trophic networks), and their tangible or intangible cultural services (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, 2019; Millennium Ecosystem Assessment, 2005). Cultural services include education, recreation, scientific, cultural, ethical, and aesthetic considerations. A cultural service of amphibians is their proposed function as environmental indicators (e.g., Welsh & Droge, 2001; Welsh & Hodgson, 2013; Welsh & Ollivier, 1998), such that changes in amphibian health or abundance may signal changes in water or on land that may have implications for broader ecosystem changes and potentially human welfare. Using herpetofauna to learn about nature is not new. They have been used to connect people to nature as they are uniquely watchable and accessible wildlife. However, we are concerned that an increasingly urban US public (i.e., a geographic sector, Figure 1) is losing direct connections to nature, including the role of herpetofauna in natural communities and ecosystem services. Such a disconnect may increase the variation in societal values toward nature and species, and specifically there may be increasing variation in herpetofaunal values among people in different communities or geographies (Figure 1). Furthermore, although positive perceptions for herpetofauna can be nurtured in educational programs, beginning in childhood (Brom et al., 2020), they may not translate to effective conservation. A recent study of French children, for example, found that the likeability of tortoises is associated with a strong willingness to protect them, but many of the children surveyed also expressed the desire to possess as a pet the very species they were inclined to protect in the wild (Ballouard et al., 2020). In other words, we cannot assume that positive perceptions and propensity to want to conserve nature (e.g., Liordos et al., 2017) will be consistent or always beneficial to herpetofauna in the wild. More targeted outreach education may be needed to raise awareness and appreciation for herpetofauna while raising awareness of their uses to people versus their conservation in natural settings.

Societal values for species in the United States align along traditionalist or mutualist dimensions. Traditionalists include attitudes of domination or use of wildlife, as people consider wildlife to be used by people; they are consumptive resources (e.g., Manfredo et al., 2018). Such traditionalist approaches contrast with emerging mutualist values for species in US society—that all species have inherent values or rights for independent coexistence with people (e.g., Manfredo et al., 2018). Manfredo et al. (2018) found that wildlife management values were shifting among residents of US states, with increasing mutualist values emerging yet considerable interstate variation as well. They found that 35% of the US population were mutualists, 28% of the population were traditionalists, 21% were pluralists with values changing with contexts, and 15% were distanced, not adhering to this value system and with low interest in wildlife. They also found rising mutualist values in urban communities, which have both community and geographic contexts (Figure 1).

Traditionalist and mutualist valuation of species goes beyond practical considerations as it also includes intrinsic qualities that may include emotional, aesthetic, and philosophical bases. These value systems may affect how people feel about herpetofauna and correspond to how much they care for their persistence when under threat of loss. This is an area of wide variation in US personal, community, or geographically based credos: across America a dual love–hate relationship with amphibians and reptiles can be encountered. People may be inspired for amphibians and reptiles by feelings of awe, wonder, and respect. During educational outreach or outdoor nature experiences, the WOW-factor with species such as amphibians and reptiles may resonate at a visceral level. For example, research found that people who participated in outdoor education programs about the American alligator (Alligator mississippiensis) altered their beliefs, attitudes, and perceptions about their ability to coexist with the predator compared to control group respondents who perceived alligators as highly dangerous to society (Skupien et al., 2016). Several herpetologists identified childhood immersion experiences as moments that led them to pursue herpetology careers (Reaser, 2009). In contrast, many people who have not had these positive or educational experiences may have reactions of uncertainty, precaution, fear, or disgust for herpetofauna (e.g., Burghardt et al., 2009). Such emotions can be reinforced by others and endure as a negative public opinion as social networks validate opinions (community × species sectors, Figure 1). Some herpetofauna become recipients of animosity; venomous snakes and other animals perceived as dangerous to humans are examples (Liordos et al., 2017).

Human perceptions, attitudes, and values of herpetofauna may not be stand-alone but exist relative to
other species. Consequently, as taxa compete for people’s time and attention, some may become forgotten as other species are considered in a more positive light and gain priority. As herpetofauna lose public attention, they may become dismissed as being of lesser importance or even disposable. After all, amphibians and reptiles were considered the “lower vertebrates” for years as compared with mammals and birds. In recent ecosystem services perspectives, herpetofauna are rarely a final ecosystem service for people, but rather an intermediate ecosystem service that helps with production of more-valued final services (Blahna et al., 2017). Intermediate services can be hidden or forgotten. This can lead to a public perception of their incidental status. In some cases, this could escalate to direct human-mediated threats. For example, in the United States, rattlesnake roundups, unregulated use of salamanders as bait, and similar unregulated use of reptiles as recreational targets for killing on roads with vehicles or in nature with firearms are well-known. These threats may have sector (Figure 1) specificity by species, community, or geographic location. Overall, social capital for herpetofauna can vary broadly with species, threats, human community, and geography (Figure 1), with this variation being a conservation hurdle that can surpass routine outreach-and-education campaigns. Such variation in social capital for herpetofaunal conservation supports Pretty and Smith’s (2004) proposal for purposeful integrated networking, especially across key societal sectors, species, and threat factors (e.g., Figure 1).

In addition to the complexity of herpetofaunal values among the broader US communities and geographies, a range of values can be echoed in the sector of wildlife management agencies charged with species stewardship roles (Figure 1). Agency decision systems may result in comparatively reduced resources afforded to herpetofauna relative to birds, mammals, and fish. The latter three taxa are part of traditional values where consumptive resources such as game species have been more valued by people in many communities. In correspondence, many agency wildlife biologists have had more formal training working with commodity-driven game wildlife and fisheries issues. Without adequate staffing and resources to monitor many rare and secretive species of amphibians and reptiles, agencies sometimes overly rely on umbrella species concepts for herpetofauna whereby they hope that protecting the habitat of a high-profile bird, mammal, or fish will also protect the herpetofauna that share those habitats; this incidental protection could have important limitations (e.g., Pilliod et al., 2020). Increasing mutualist values in US society may necessitate a concomitant change in US state wildlife management to better align with contemporary public priorities. To incorporate shifting patterns of societal valuation of wildlife in management priorities, “inreach” activities may be needed, where inreach includes inward-facing informational campaigns to natural resource managers and agency leads to recognize and reconcile the potential growing social conflict of traditionalist-mutualist stewardship priorities. As part of such inreach, the conservation concerns for herpetofauna can be raised as emerging conservation priorities across taxonomic groups are broached. Inreach may be particularly useful when fish and wildlife agencies have reduced staff or funding for herpetofauna and in geographies and communities with rising mutualist values (Manfredo et al., 2018).

Programmatically initiating species- or issue-specific based efforts could provide important steps toward sustainability of this fauna. In practice, development of effective species conservation programs relies on numerous implementation considerations (Olson, 2007), including programmatic prioritizations of species and their threats, which can leverage both socioeconomic resources (i.e., funding, infrastructure, and personnel) and authority (legal foundations and institutional purview) to guide and enforce management actions. If there is reduced institutional programmatic infrastructure for herpetofauna conservation capacity yet rising mutualistic values in the human population, inreach could reveal the disparity. Yet, when resources are limiting, a struggle over species values within wildlife agencies can result (e.g., Coser, 1967). Facilitating reductions in such social conflict could aid broader species conservation effectiveness (Niemiec et al., 2021) and address paths to increase stewardship potential, possibly with engaged stakeholders across multiple sectors (e.g., Figure 1).

Herpetofaunal threats also may emerge under the domain of agencies that do not directly manage wildlife. For example, renewable energy development is a growing concern for desert wildlife, including reptiles. Thousands of photovoltaic solar arrays now cover vast areas, directly altering solar radiation reaching the ground surface where reptiles live (e.g., US southwest: Lovich & Ennen, 2011). These massive solar farms have the potential to alter the thermal environment, creating unsuitable reptile habitat and affecting communities such as by reducing prey populations upon which reptiles rely. Altered climates from a variety of natural and anthropogenic disturbances are a particular concern for ectothermic vertebrates (e.g., reptiles: Barrows et al., 2016; Huey et al., 2010; Shoo et al., 2011; Sinervo et al., 2010), adding complexity to integrate joint inreach–outreach efforts among communities, geographies, and management agencies for herpetofaunal conservation.

Research is the final sector integrated with society, managers, and species at risk (Figure 1). Alas, “more research is needed” may become an epitaph for herpetofauna. Urbina-Cardona (2008) reported that there may be a lower incentive for scientific research in herpetology due to the
relatively lower impact factor than other biological sciences, hence reduced rewards for scientists relative to outcomes of their efforts. Although an uptick of amphibian research has been noted (Angelini et al., 2020), relative to birds, mammals, and fishes, biological and ecological research of both amphibians and reptiles has lagged. This suggests that traditionalist and mutualist philosophies could be evident in research institutions as well. For example, the first Global Amphibian Assessment categorized 23% of amphibians as having insufficient information to assess conservation status (i.e., data deficient: Stuart et al., 2008). Of the 45% of reptile species that have been assessed by IUCN, 19% were data deficient (Tingley et al., 2016). At a basic level, species life history and occurrence data are depauperate but necessary data upon which species status assessments are based. To document threats or declining populations, trend assessments over time are needed. Optimally, a trend for declining populations is based on data extending more than one generation time (Blaustein et al., 1994). For long-lived, slow-developing species of amphibians and particularly reptiles, one generation time can span a decade or more. Such long-term datasets for the >600 species of US herpetofauna are rare. Enhanced social capital might reinvigorate this foundational aspect of herpetofaunal research programs.

By its very nature scientific research related to herpetofaunal conservation is an integrated societal construct, touching upon several other sectors of Figure 1. In addition to communication between scientists and managers relative to species conservation issues, several other human dimensions are at play. Peer-reviewed, published studies inform management decisions, but they are enmeshed in additional social constructs and constraints. To obtain partners or funding, research proposal success may rely on an individual scientist’s or institution’s social capital, with those entities also having an accompanying intricate social structure, priorities, and process loops. Research implementation often relies on social processes per study or institution, and completed studies are published in peer-reviewed outlets to ensure adherence to interdisciplinary science cultures and standards. Then, those papers may gain recognition through peer recognition and social media networks, including a feedback loop to direct interactions between scientists, managers, and the public. The caricature of the ivory-tower scientist toiling alone for knowledge discovery must change if social networks are key to conservation-science success. Scientific research could become a key integrator of the sectors in Figure 1, as each already can have a role in the research cycle. For example, in a review of the human dimensions of coexistence with crocodilians, Cavalier et al. (2021) proposed that researchers work with decision makers to “unearth the socio-political mechanisms that promote reverence and respect for crocodilians, reconcile at least an urban paradox prioritizing the human system over crocodilians, and unlock governance designs that champion resiliency in both crocodilian and human systems.”

3 | ELEVATING HERPETOFAUNAL CAPITAL

The role of people in US herpetofaunal conservation is at a pivotal moment. Anthropocene processes are accelerating species threats, while globalization practices pose new challenges for ecosystem integrity with increasing exploitation of species for food, pets, medicinal products, and biotic homogenization of communities from invasive species (Penaluna et al., 2017). Simply the lack of connections between people and herpetofauna at several levels may be a harbinger for their more rapid losses in an era of competing public interests for limited resources. Reduced programmatic attention is concerning for herpetofauna as natural resource managers, policy makers, and research institutions prioritize ever-more-limited funding resources or capacity toward more iconic and economically important species. If public resources are further prioritized elsewhere, herpetofaunal conservation threats could be magnified, potentially past a level where ecological recovery is attainable. Lowering herpetofaunal conservation hurdles and elevating potential solutions are key to improving their conservation capacity.

A renewed focus on US herpetofaunal conservation across all five interwoven human sectors (Figure 1) could recast outcomes for rare species at risk of extinction with a socially embedded, adaptive learning process such as that proposed by Pretty and Smith (2004). Engaging citizens and private landowners in the process of species conservation is a critical step in increasing social capital, sometimes for tangible, pragmatic reasons. Conservation of the gopher tortoise (Gopherus polyphemus) in the southeastern US, for example, depends upon private landowners because the region is predominantly under private ownership. A mail survey revealed that landowners in that area were largely unaware of the habitat requirements of tortoises or the effects of land management practices on the species (Underwood et al., 2012). Although the majority of respondents knew about wildlife incentive programs provided by state and federal agencies, they were hesitant to enroll because they did not want to commit to managing their property in a particular manner; without further engagement, this process could have stagnated. With an eye to gains in social capital for amphibians and reptiles, innovative solutions for social networking among scientists, managers, policy makers, conservation organizations, landowners, and
concerned people across diverse communities and geographies could provide momentum for improved conservation effectiveness. Two strategies in the United States are currently being trialed with some success.

First, the Network Growth strategic goal of Partners in Amphibian and Reptile Conservation (Partners in Amphibian and Reptile Conservation [PARC], 2021d) is focusing attention on broadening herpetofaunal social networks. Furthermore, PARC’s rotating-image approach of changing issues-of-emphasis is a strategy that can counter conservation fatigue and changing values of human communities (e.g., traditionalist vs. mutualist, as mentioned above), while spreading resources across species and geographies warranting attention. This approach can help connect various societal sectors (Figure 1). International Amphibian Week gained broad participation in May 2021, including a US government proclamation from the Department of Interior for amphibian conservation stewardship across the nation (PARC, 2021a). Past year-long international celebrations have included Year of the Turtle in 2011, Lizard in 2012, Snake in 2013, and Salamander in 2014 (Partners in Amphibian and Reptile Conservation [PARC], 2021c). These have varied the taxa-of-emphasis and have echoed contributions of diverse managers, scientists, educators, and communities, hence integrating diverse societal sectors around a taxon of interest each year. Furthermore, PARC’s new emphasis on human diversity, equity, and inclusion in their efforts is helping to further connect across sectors, while promoting human diversity in those sectors as well (Figure 1). Connections of like-minded people across sectors (Figure 1) are established through these efforts and can have long-term benefits, often creating diverse approaches to the social science of conservation for broad natural systems (Bennett, Roth, Klain, Chan, Christie, et al., 2017; Bennett, Roth, Klain, Chan, Clark, 2017).

Second, integrated task teams for coproduction of amphibian and reptile research and conservation efforts are also gaining efficacy and addressing social dimensions. This is illustrated by the structure and composition of the North American Bsal Task Force (Figure 2), an interdisciplinary and international volunteer group to focus research, management, and interdisciplinary communication on one disease threat caused by the amphibian chytrid fungal pathogen Batrachochytrium salamandrivorans (Bsal; Bsal Task Force, 2021; Grant et al., 2015, 2017). Bsal is an emerging pathogen from Asia that has caused population declines in several salamander species in Europe, but has yet to arrive in North America, a global hotspot of salamander biodiversity (Waddle et al., 2020). With annual publications from sub-disciplinary working groups, the Bsal Task Force has ongoing efforts to actively manage social capital regarding this threat across several sectors in Figure 1. Both PARC and the North American Bsal Task Force are similar in that they have multiple stakeholder participants and social media presence, allowing ongoing messaging to established and newly interested social networks. Furthermore, another group, PARC’s National Disease Task Team, interfaces with both PARC and the Bsal Task Force to pick up topics outside their purviews (Partners in Amphibian and Reptile Conservation [PARC], 2021b), and leverage the scope of work for Bsal to a range of other herpetofaunal diseases and health conditions. For example, their Herp Disease Alert System allows email communications of apparent herpetofaunal disease die-offs in North America to expedite reports to US state and Canadian provincial authorities for potential action (Gray et al., 2018). Recent field biosecurity papers and factsheets are highlighting select diseases and what scientists, managers, and the public can do to forestall herpetofaunal disease threats (Gray et al., 2017; Julian et al., 2020; Olson, Haman, et al., 2021; PARC, 2021b).
Networking for US herpetofaunal conservation goes beyond broad-based national teams to regional and local scales. For example, in the Mojave Desert of the US Southwest where sustainable energy and other threats may affect reptiles, proactive efforts of land-use analyses (Cameron et al., 2012) and multi-stakeholder teams (Averill-Murray et al., 2012) are working toward developing solutions to accommodate both sensitive species and a green energy economy. The Southwest regional working group of PARC helps facilitate some of this communication, outreach, and inreach.

Beyond the often-complex science–management interface, strides in the human dimension of amphibian and reptile conservation relies on all people, children-to-elders across communities, with specific efforts for human diversity and inclusion. In an increasingly urbanized culture and distancing of people from wild places, Pope and Piovia-Scott (2017) captured a focal point for many conservation efforts relative to amphibians, but it applies to reptiles as well: “In order for amphibian conservation to stay relevant, we need to gain support from the American public, especially the young.” The associations of the mutualist wildlife value system with urban societies (Manfredo et al., 2018) may help in this regard. It is useful to remember that in our human future, for our children’s children, we will never have as much biodiversity as we have today, underscoring the need for communities to make a difference now for those taxa experiencing rapid declines, such as many species of amphibians and reptiles.

4 | CONCLUSION

Effective herpetofaunal conservation is needed now, with globalized anthropogenic changes accelerating biodiversity loss. For amphibians and reptiles in the United States, the future is likely more dire compared to other vertebrates as they are often neglected taxa, garnering less attention, falling through cracks in natural resource management systems due to their lack of social capital, especially when traditionalist values guide wildlife management priorities. Elevating the increasing threats to amphibians and reptiles across diverse societal sectors can provide conservation inertia, as all people and their interactions are intrinsically intertwined with conservation research and threat management. Improving the common-public valuation of amphibians and reptiles with inreach and outreach efforts via single species- or issue-specific programs can help enhance conservation capacity; conservation effectiveness increases when people care. Engaging scientists, wildlife managers, educational personnel, landowners, and the public in local, regional, and national teams can raise the portfolio of priority needs and reimagine effective herpetofaunal conservation. This may be the only way to turn the tide on population declines and truly safeguard amphibian and reptile species from extinction.

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CONFLICT OF INTEREST

The authors have no conflict of interest to declare.

AUTHOR CONTRIBUTIONS

Deanna Olson and David Pilliod equally conceptualized the paper. Deanna Olson developed and refined the framework for the paper, and David Pilliod contributed to the literature review and significantly edited each draft of the manuscript.

DATA AVAILABILITY STATEMENT

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