

A perspective on amphibian conservation in the United States

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In the United States of America, the connection between science and policy can be thin, tenuous and capricious. Despite the fact that some of the best work in conservation biology in this country has involved amphibians, with several notable exceptions (particularly in California, but also scattered elsewhere), this science has not been translated into widespread, on the ground, amphibian conservation initiatives. That is, by themselves, across most of the United States, amphibians have not yet shown they carry the economic or emotional clout to save amphibians. One way out of this dilemma is to work from the broader perspective of amphibians as critical components of important ecosystems. To do this, amphibian conservation biologists should continue their essential work centered on amphibians, but also consider increasing efforts to join forces with other groups holding shared interests. Many candidate cooperative groups are oriented around game and fish, which are commercially important and have been able to weather the policies of both sides in the current malevolent bipolar political climate in this country. Game- and fish-oriented allies would offer hope for amphibians in all areas of the country, and in all political climates, not just those favoring environmental interests.

INTRODUCTION

In the United States of America, scientists are respected but, in the contentious realm of environmental policy, their work is often overshadowed by non-scientific influences. Politicians can court a substantial number of voters by taking an anti-intellectual stance; emotion and anecdote, properly placed, can sway legislators more than clear thinking and logic, and economic issues usually trump environmental concerns. In this country at this time, the connection between science and policy is often thin, tenuous and capricious. For example, while climatologists are overwhelmingly convinced that global warming is occurring, television meteorologists largely remain skeptical (KAUFMAN, 2010). With environmental issues, the link between science (especially basic science) and policy is filtered through the media (SOUDER, 2005). Therefore it often takes images – with emotion swaying public opinion – for scientific findings to influence public policy.

THE AMPHIBIAN PERSPECTIVE

Despite being a poster-child for global biodiversity and beloved by children throughout the world, amphibians face a bleak future. The roughly 6,000 species of amphibians face a large number of challenges if they are to maintain their celebrated global diversity (WAKE, 1991; COLLINS & STORFER, 2003; STUART et al., 2004; WAKE & VREDENBURG, 2008; COLLINS & CRUMP, 2009; HAYES et al., 2010a). Most of these challenges are human induced, and include habitat loss, habitat fragmentation and habitat alteration, as well as susceptibility to man-made chemicals, disease, invasive species, UV-B radiation and climate change. Despite all of the data that have been gathered, the knowledge that has been accrued, and the awareness that has been generated, policies towards amphibian conservation in most areas of the United States have not dramatically changed. Why? In part, because amphibians have little direct economic or emotional impact, and as both individuals and a society, we in this country tend to be driven by money and emotion.

Never mind that we know habitat loss, alteration, and fragmentation associated with the presence of humans are clearly major, accelerating, causes of global amphibian declines (GALLANT et al., 2007). We know that since the beginning of the 20th century and the advent of modern medicine, human population growth has been exponential and has occurred largely in the subtropical and tropical ecoregions – the same habitats favored by amphibians (GALLANT et al., 2007). Regions of high human population growth often overlap with biodiversity, including amphibian hotspots (PIMM & RAVEN, 2000; STUART et al., 2004; GALLANT et al., 2007). Human population growth rates within these hotspots are significantly higher than the population growth rate of the world as a whole, even greater than in areas immediately surrounding these hotspots.

Never mind that we can show that this human population growth is accompanied by large-scale changes in land cover and land use (MEYER & TURNER, 1992; DEFRIES et al., 2002; GALLANT et al., 2007). The relationship between human population growth and loss of amphibian habitat is simple – people alter the landscape through their needs for food, shelter, fuel, livelihood and lifestyle (HEILIG, 1994; BONAN, 1999; MARSHALL et al., 2003; RICKETTS & IMHOFF, 2003; GALLANT et al., 2007). Localized changes effected by human activities have direct impacts on amphibian habitat availability, quality and function through habitat loss (e.g., deforestation), habitat fragmentation (e.g., road building) and habitat alteration (e.g., pollution). While many organizations are fighting to save tropical ecosystems, and while many people are aware of the plight of amphibians in these ecosystems, with few exceptions amphibians are not driving these conservation efforts. Nor are amphibians driving policies toward land preservation on regional, continental, or global scales, although there are many examples of local tracts of native or restored habitats being preserved to save populations of threatened or endangered amphibian species.

Never mind that we know invasive species have been particularly problematic for wetland breeding amphibians. In North America, invasive species include non-natives (e.g., African clawed frogs, *Xenopus laevis*) and natives now inhabiting non-native ranges (summarized in LANNOO, 2005). Here, bullfrogs (*Lithobates catesbeianus*) are the most notorious of native invasive species, a scourge both in the western United States and throughout many portions of

the world. But perhaps the invasive species group that has most influenced amphibian abundance and distribution has been introduced game and bait fishes. This is a problem nearly everywhere; in the United States impacts have been detailed in the Midwest (LANNOO, 1996) and throughout the Sierra Nevada mountains of eastern California (BRADFORD et al., 1993; VREDENBURG, 2004; KNAPP, 2005). As desirable as policies against moving aquatic species would be (not only to prevent invasive species, but also to slow the spread of disease), there are few regulations in place to prevent federal, state, or private aquaculturists from transferring fishes wherever they want to (although National Park Service biologists in the Sierra Nevada Mountains have recently undertaken costly efforts to remove stocked game fish in order to help preserve endangered mountain yellow-legged frogs [*Rana muscosa*]).

Never mind that we have much evidence to show that man-made chemicals have severe, profound effects on amphibians, ranging from endocrine disruption, to other forms of physiological dysfunctions, to disturbing morphological malformations, to death. We know that different life history stages can present variable sensitivities, and the effect of chemical combinations or cocktails can be additive or synergistic. Chemical effects on amphibians have driven public policy, for example the total or partial bans of Round-Up® sales or applications by Australia, Denmark (ANONYMOUS, 2010a), the Canadian province of Ontario, and the United States city of Oakland, California; and the Atrazine ban by the European Union (ANONYMOUS, 2010b).

Never mind that we have evidence to show that UV-B effects on amphibians, although temporally and spatially variable (BLAUSTEIN et al., 1996, 2000; BROOKS et al., 2005; LANNOO, 2008), have the potential to be universal, with impacts that can be either direct or indirect. Direct effects can include severe morphological malformations, as well as biochemical and physiological malfunctions, which reduce fitness or lead to death. Indirect effects include the breakdown products of xenobiotic chemicals. UV-B is known to increase the toxicity, and therefore the teratogenic effects, of polycyclic aromatic hydrocarbons (FERNANDEZ & L'HARIDAN, 1992), and the retinoid S-methoprene, used to inhibit insect (mosquito) metamorphosis (LA CLAIR et al., 1998). These effects are especially threatening to amphibian embryos and larvae (HATCH & BURTON, 1998). Yet, despite this knowledge, in public opinion the effects of UV-B radiation on amphibians have been secondary to effects on human health; that is, amphibians have not been drivers in the movement to eliminate the use of chlorofluorocarbons, bromine-containing compounds, and other sources of ozone-depleting chemicals.

Never mind that we know that a variety of diseases annihilate amphibian populations. Early in the investigation of amphibian declines, an emphasis was placed on “mysterious” causes of declines—declines in regions where the habitat was thought to be “pristine” (we now know that the influence of man is global, and thanks in large part to emerging infectious diseases as well as the global spread of contaminants there are no remaining pristine environments left on earth). Policies such as CITES (ANONYMOUS, 2010c) restrict the flora and fauna trade and may slow the spread of disease (JONES et al., 2008; PAVLIN et al., 2009; SMITH et al., 2009). But in a free-trade world, once disease becomes established anywhere it must inevitably become established just about everywhere there are favorable conditions. While researchers may wash and bleach boots, nets and buckets in an effort to avoid transporting the aquatic-based chytrid fungus (*Batrachochytrium dendrobatidis*), and some environmentally aware anglers, hunters, birdwatchers and hikers may clean boots and gear between sites for

reasons other than amphibian disease transmission, coyotes, raccoons, minks, wading birds and waterfowl most certainly do not.

Never mind that the United States has laws such as the Endangered Species Act (ESA; enacted in 1973), Clean Air Act (enacted in 1970) and Clean Water Act (enacted in 1972) designed to preserve and protect species such as amphibians and their environments. In this country, governmental policy apparently does not have to follow laws established by democratic processes. The same political party that tends to view leadership by the opposing party as illegitimate also tends to view environmental laws as something akin to communism – the enemy of capitalism and free enterprise. For perspective, ask any US Fish and Wildlife Service (USFWS) personnel about the way their job responsibilities ping-pong back-and-forth depending on which political party is in power.

Whereas there are currently 22 amphibian species listed as federally threatened or endangered (ANONYMOUS, 2010*d*) in the United States and their territories (we celebrate this and the protection the ESA affords these species), there are easily two or three times this number that should be listed. The problem is that conservation needs alone do not drive the endangered species listing process: liberal regions of the country, public land ownership and environmentally friendly governments (or at least their constituencies) favor listing. California has been a model of how federal laws can work to afford amphibian protection. Of the species currently federally listed, 19 are from the continental United States, and of these 7 (37 %) are from California – a disproportionate number. California has the advantages of a high density of remarkable herpetologists drawn from academic, federal and state ranks; citizens groups and NGOs that spring to action and are willing to litigate to ensure that laws are enforced; and vast expanses of private lands. In the Great Plains, the Midwest, and in the Northeastern and the Southeastern United States (where the majority of amphibian species reside), there are lower densities of academic herpetologists (exceptions occur around major universities and their field stations), few state herpetologists and few federal herpetologists. In the Northeast, citizens' action groups and activism may rival that seen in areas of the West Coast, but the Great Plains, Midwest and Southeast tend to be conservative regions; further, none of these areas support the vast expanses of public lands enjoyed farther West.

One case study showing how the ESA works in the East will serve as an example (there are more; some present this process in a better light, others do not). In 1982, the USFWS designated the Mississippi gopher frog distinct population segment (*Rana capito sevosa*) as a candidate for category 2 (threatened) listing, and solicited status information. Nine years later (1991), USFWS biologists proposed category 1 (endangered) status, which was approved ten years after (2001), when Mississippi gopher frogs were thought to be reduced to a single breeding population (ANONYMOUS, 2001). Also in 2001, this population was determined to be a separate species, the dusky gopher frog, now designated *Lithobates sevosus* (YOUNG & CROTHER, 2001; CROTHER, 2008). After another nine years passed (in 2010), USFWS biologists finally proposed designating critical habitat for these animals – as mandated by the 2001 ruling – after being sued by citizens' groups to do so (ANONYMOUS, 2010*e*). From the time of first concern by federal biologists to the designation (but not, as yet, the application) of critical habitats took nearly 30 years, roughly 8–10 dusky gopher frog generations. Currently, dusky gopher frogs are restricted to one modest natural population, one or two small peripheral populations (origins unknown), and a repatriated population (ANONYMOUS,

2010e). While “budgetary and workload constraints” were listed as causes of these delays, rank-and-file field biologists – the folks whose names appear in the Federal Register notices – cannot be held accountable; so much of their time is now devoted to addressing regulatory issues that they have few resources and insufficient budgets to recover species. Instead, it is important to recognize that, for 20 of these past 30 years, federal biologists have been working under administrations unwilling, at best, to support these actions.

Additional efforts to propose category 2 listing for two closely related species, gopher frogs (*L. capito*) and crawfish frogs (*L. areolatus*), have been discouraged because of the potential negative effects of being listed on populations inhabiting private lands (the majority of land in the East). In conservative states and in the conservative portions of liberal states, landowners may prefer to eliminate populations of endangered species rather than have the “gavamint” dictate land use. The presence of the ESA and this response by landowners has helped to formulate a new strategy – employing species action plans, conservation plans and recovery plans – which seeks a middle ground. In exchange for not listing a species (viewed in this light as a last-ditch effort), partners, including landowners, agree to cooperate in conservation efforts. Whereas this strategy is viewed as a pragmatic compromise, from the perspective of the species being considered it lacks the legal muscle of the ESA. In sum, amphibians in the United States need strong laws (these, they have) consistently applied across regions and political philosophies (these, they do not have). Given this gap, amphibians in the United States must find some means to weather unfavorable political climates, whether they be temporal or spatial.

WHY ISN'T THE GLOBAL DECLINE OF AMPHIBIANS A MAJOR DRIVER OF ENVIRONMENTAL POLICIES?

There are several reasons, including the limited public appeal of amphibians compared with birds and mammals, having few keystone or umbrella species, the lack of broad-scale, long-term commitment from resource agencies, and, probably, politics at all levels. Fundamentally, it is essential to realize that in a free market society, amphibians are not deemed vital simply because they cannot pay their way. For example, migratory birds and sport fish benefit from hunting and fishing license dollars. By law, these dollars must be spent only on birds, mammals and fish (fish are statutorily defined as “fully aquatic, gill breathing vertebrates with paired fins”). Thus, whereas many other non-game species (plants and animals, vertebrates and invertebrates) can benefit from these dollars, amphibians (and reptiles) technically cannot. Currently, there are no revenue sources specifically targeted to benefit amphibian conservation, although USGS (US Geological Service) biologists currently receive funding to support their Amphibian Research and Monitoring Initiative (ARMI; <<http://armi.usgs.gov>>).

No less importantly, whereas we have our champions, such as George Rabb, Dave Wake and Whit Gibbons, who care deeply and have raised awareness of amphibian conservation issues (Tyrone Hayes has become part rock star and part cult hero for his war on Syngenta; HAYES, 2010), there has been a lot of contention among rank and file biologists. In a 1929 letter, Aldo Leopold wrote that the fundamental weakness of the conservation movement is

that its practitioners come to value their personal prestige more than conservation (MEINE, 1988; LANNOO, 2010). In the intervening 80 years this situation has not changed much. Major, and very public differences in opinion have been expressed about the relative importance of just about every cause of amphibian decline or malformation. (In fact, herpetologists cannot even come to an agreement on the scientific names of some of the most common and well-known North American amphibian species – CROTHER, 2009; FROST et al., 2009; PAULY et al., 2009). For example, the icon for global amphibian declines, the golden toad (*Incilius periglenes*), was a tropical, montane cloud forest species, whose extinction signaled the beginning of the amphibian decline crisis. Anyone concerned about the cause of the extinction of these beautiful animals is likely to be deeply confused, as scientists advocating climate change (POUNDS et al., 1999, 2006) and El Niño (ANCHUKAITIS & EVANS, 2010) effects wage a very public debate (PAGE, 2010). It is difficult for science to influence policy when multiple explanations are on the table and personalities speak louder than data. Generally these battles do not pit one cause against the other so much as they pit single causes said to apply everywhere against a broader, more open approach that allows for nuance. In perhaps the most famous scientific quote of all time, Thomas Henry Huxley responded to the fall of Herbert Spencer’s notion of social Darwinism with the comment “*A beautiful hypothesis destroyed by a nasty, ugly little fact*” (GOULD, 1998). Given the workings of the scientific method, Huxley’s quip will always come true, even if it takes the perspective of a future generation. The problem is, the amphibian decline crisis is happening now.

HOW CAN WE MAKE AMPHIBIANS CENTRAL TO CONSERVATION POLICIES?

Amphibians greatly benefit from efforts to save land for other species or recreational uses. In the United States, many agencies and institutions, including the Bureau of Land Management, National Park Service, National Forest Service, Military Bases, National Wildlife Refuges, and state fish and wildlife areas, provide large tracts of undisturbed land used by both common and threatened amphibian species, and in fact several of these agencies have provided funding, directly or indirectly, for amphibian conservation (e.g., LOVICH et al., 2010). Further, the State of Iowa has recently established an Amphibian and Reptile Conservation Area, outside the town of Bluegrass. On private lands, the move towards land trusts and federal agricultural (“Farm Bill”) programs administered through the National Resources Conservation Service has the potential to assist amphibians.

Because amphibians cannot fly or otherwise cover great distances of uninhabitable landscapes unaided, they depend on connections between suitable habitat types. This is especially true of amphibian species (the majority) with complex life histories. These animals must be able to navigate between spring aquatic breeding sites, summer terrestrial feeding sites and overwintering areas that may be either terrestrial or aquatic. Furthermore, not only must land be available, to be habitat it must also be healthy (sensu LEOPOLD, 1949; see KILPATRICK et al., 2010). Healthy landscapes are expansive, free of disease (LIPS, 1998, 1999; LIPS et al., 2006; PATZ et al., 2004; RACHOWICZ et al., 2006), free of invasive species, and free of chemical contamination through direct application, runoff, or drift (HAYES et al., 2002*a-b*, 2003, 2010*b*;

RELYEA & JONES, 2009). By including amphibians as major interests in conservation policies we ensure landscape-level protection.

THE STATE OF AMPHIBIAN CONSERVATION IN THE UNITED STATES

In the United States, many amphibian conservation efforts are in operation, reflecting different geopolitical scales. The IUCN's (International Union for Conservation of Nature) Amphibian Specialist Group represents a global effort. With the assistance of Conservation International and NatureServe, which has long had an interest in preserving amphibian biodiversity, IUCN produced the Global Amphibian Assessment (now Amphibians on the IUCN Red List; STUART et al., 2004) and the IUCN Red List of Threatened Species (ANONYMOUS, 2010f) represents the definitive authority on the global status of all amphibian species. The IUCN's Species Survival Commission (SSC) produced the Amphibian Conservation Action Plan (GASCON et al., 2007), and in 2011 formed the Amphibian Survival Alliance with its goal of more fully implementing the Amphibian Conservation Action Plan. Further, the Amphibian Specialist Group has taken over the IUCN's widely read Declining Amphibian Populations Task Force (DAPTF) publication, *Froglog*, and DAPTF's impressively effective seed grant program. The Association of Zoos and Aquariums also represents a global community committed to the preservation of amphibians. Amphibian Ark is a joint effort of the World Association of Zoos and Aquariums (WAZA), the IUCN SSC Conservation Breeding Specialist Group (CBSG) and the IUCN SSC Amphibian Specialist Group (ASG). Their mission is to ensure the global survival of amphibians, focusing on species that cannot currently be safeguarded in nature. Amphibian Ark established the Year of the Frog campaign in 2008 to publicize the plight of amphibians through its vast array of member institutions. Amphibian Ark also has a seed grant program. AmphibiaWeb is an international website hosted by the University of California that provides access to information on global amphibian declines, as well as amphibian conservation, natural history and taxonomy.

At the national level, Partners in Amphibian and Reptile Conservation (PARC) was conceived by concerned scientists, resource managers, and other conservation-minded individuals to help bring scientists and managers together. PARC, modeled after Partners in Flight, seeks to effect amphibian (and reptile) conservation through partnerships with state and federal agencies, non-governmental organizations (NGOs), business groups including the timber industry, pet trade and other interested parties.

The most important function of these groups in the United States has been to raise awareness of amphibian (and often reptile) conservation issues through meetings – sometimes general, sometimes targeted to specific issues, at local, regional and national levels – programs, and publications ranging from field guides and status assessments to management guidelines and monitoring protocols. Another important function of these groups has been to mobilize support for amphibian conservation efforts in certain regions of the country, for certain issues, or among groups previously disengaged or less engaged. These groups have also provided funding, for example through seed grant programs, special initiatives, or an association with the National Fish and Wildlife Foundation.

AMPHIBIANS CONTINUE TO DECLINE: WHERE DO WE GO FROM HERE?

Each of the groups highlighted above represents a collection of enormously talented and dedicated professionals working on behalf of amphibian conservation. The reason we understand so well the overall importance of amphibians to ecosystems and the threats to their continued existence is through the hard work and tireless commitment of these people. Yet, despite these numerous, and sometimes heroic, efforts, amphibians continue to decline (BEEBEE & GRIFFITHS, 2005; WAKE & VREDENBURG, 2008).

Unless we can make a new type of human (Aldo Leopold in LUTZ-NEWTON, 2008), it seems unlikely in our self-possessed world (LANNOO, 2010), and in the current bipolar political climate of the United States, that amphibians, by themselves, will effect the sort of changes necessary to conserve amphibian species richness; amphibians simply do not carry enough economic or emotional clout. Instead, I suggest that rather than effect amphibian conservation solely from the perspective of amphibians, that amphibian conservation biologists expand their scope. While continuing to support the key amphibian conservation groups and initiatives highlighted above, I suggest we reinforce these efforts by working from the broader perspective of amphibians as critical components of important ecosystems. To do this, amphibian conservation biologists should ramp up efforts to join forces with other groups through shared interests. Habitats critical for amphibian species include wetlands (especially fishless wetlands), streams, rivers and their backwaters, the littoral zone of lakes, tall- and shortgrass prairies, and forests of all types. From my perspective, fish and game areas and the organizations that support them offer excellent opportunities for amphibian conservation. Many fish and game species confront the same threats facing amphibians. On one of our study sites (729 ha) in southwestern Indiana – a coal-spoil prairie bought by hunter and angler dollars and managed for fish and wildlife uses – we have now discovered 33 species of amphibians and reptiles, including two state-endangered species, three species of special concern, and 11 new county records (LANNOO et al., 2009; KINNEY et al., 2010). This was a surprise to everyone, and this level of herpetofaunal species richness is likely not unique to this particular wildlife area. There is hope in this, and despite the perspective presented here, my colleagues and I continue to have hope. By identifying problems we begin the process of conjuring solutions. No one I know is throwing in the towel.

As mentioned above, amphibians across the United States must find some way to weather unfavorable political climates, whether they be temporal or spatial. Game and fish interests have managed to do this, and amphibians could benefit from cooperation with these organizations. Groups to be targeted could include Ducks Unlimited and Delta Waterfowl – hunter organizations primarily concerned with waterfowl conservation – that have conserved hundreds, if not thousands of amphibian communities throughout the Prairie Pothole Region of North America. Trout Unlimited has been a strong advocate of clean water regulations. This group has also been a force in educating anglers about the value of native fish in their native habitats and has consequently been a strong opponent of fish introductions – a view that assists amphibians through a reduction in invasive species and disease spread. Pheasants Forever, which accurately calls itself the “habitat conservation organization”, has been particularly vocal in advocating farm bill programs such as the Conservation Reserve Pro-

gram (CRP) and the Wetlands Reserve Program (WRP). In addition to these organizations, The Nature Conservancy has been crucial in purchasing key tracts of land; we know of at least one five-acre tract in Indiana (Salamander Swale in Henry County) that was specifically bought to conserve a population of four-toed salamanders (*Hemidactylium scutatum*).

In the most enlightened approach to land management we have yet encountered, Ron Ronk, Indiana Department of Natural Resources land manager responsible for our Indiana study site, resists effecting single species management practices. He says: “*The animals are here because the ecosystem is here. I try to manage for natural ecosystems, not single species.*” Whereas the future of many rare or geographically circumscribed species of United States’ amphibians lies in the sometimes heroic species-centered conservation initiatives being undertaken by the groups highlighted above, the future for many common amphibian species in United States may lie in the politically buffered results of ecosystem conservation practices broadly applied.

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