

Amphibian Declines: An Issue Overview

About This Guide and How To Use It

The purpose of this guide is to provide a general overview of the amphibian decline issue. In particular, it highlights the geographic extent, severity, causes, and consequences of the problem. As well, it identifies actions that can be taken toward problem resolution. While this guide assumes the reader has a basic knowledge of amphibians and conservation issues, it is intended for use by a wide variety of stakeholders — government agencies, non-governmental organizations, academic institutions, private industry, and funding foundations. It will be especially useful to those intending to work within the United States.

This guide is meant to serve as a springboard for additional efforts toward amphibian conservation. There is an urgent need to translate the information presented here into products for specific audiences — to effectively reach such groups as policy makers, resource managers, and children.

The guide is designed in three units: 1) a narrative overview of the issue; 2) a series of brief facts on amphibians, amphibian declines, and problem resolutions; and 3) a listing of resources for further information. The narrative overview provides the basis for developing an oral presentation on the subject. The facts in brief and list of resources can be photocopied and distributed as stand alone “fact sheets.”

The reader’s challenge is to identify the means by which he or she can personally work to conserve amphibians sooner rather than later.

TADD - Federal Taskforce on Amphibian Declines and Deformities
PARC - Partners in Amphibian and Reptile Conservation
DAPTF - Declining Amphibian Populations Task Force
ACA - Amphibian Conservation Alliance

Amphibian Declines: An Issue Overview

This guide is released as a joint publication of the Federal Taskforce on Amphibian Declines and Deformities (TADD), Partners in Amphibian and Reptile Conservation (PARC), the Declining Amphibian Populations Task Force (DAPTF), and the Amphibian Conservation Alliance (ACA).

On the cover from top to bottom: *Rhacophorus* sp., (treefrogs from Taiwan), in amplexus (©Jamie K. Reaser); *Plethodon cylindraceous* (slimy salamander)(©Jamie K. Reaser); *Bufo* sp. (toad) (Donna Foulke).

The clearance process for this guide included a review of the text by members of the TADD, PARC, DAPTF, and ACA.


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Columbia spotted frog (*Rana luteiventris*)

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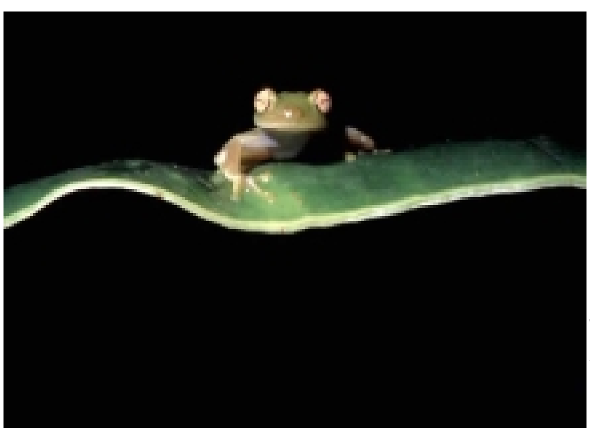
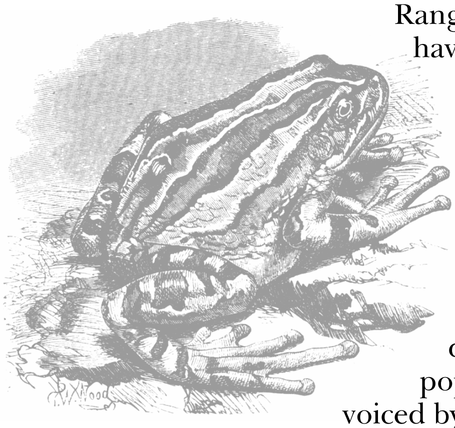


Treefrog from South America (*Hyla granosa*)

Executive Summary

Amphibian Declines

Amphibians, a class of vertebrates that includes frogs, salamanders, and caecilians, are amazing. As a group, they have been on this planet long before and ever since the dinosaurs. Various amphibian species have adapted to live in wetlands, forests, deserts, savannas, agricultural landscapes, and cities. Yet all of a sudden, many amphibian populations are declining around the world.



Ranges of many species have been dramatically reduced and species extinctions have occurred rapidly, even in “protected” areas.

Concern for the apparent worldwide decline in amphibian populations was initially voiced by the international community in 1989 at the First World Congress of Herpetology, held in England. At this meeting, participants presented scientific papers and exchanged personal accounts of amphibian declines and disappearances. Based on the information presented at this and subsequent meetings, amphibian researchers concluded that the number and geographic extent of the reports indicated that the situation should be approached as a potential environmental crisis.

In the decade that has followed, amphibian declines have indeed come to be regarded as an ecological emergency in progress. What is wrong with our planet? Could the thinning of the atmosphere’s protective ozone layer be increasing exposure to ultraviolet radiation? Could this be a sign that global warming is in progress? Are diseases newly emerging or being transported further and faster from their points of origin? Although many such questions have yet to be answered, several “culprits” have been clearly identified:

- climate change
- habitat loss and fragmentation
- introduced species (especially fish and bullfrogs in the western U.S.)
- contaminants (especially biocides)
- ultraviolet radiation (UV-B)
- acid precipitation
- disease
- unsustainable harvest and trade

Why Care?

Amphibians provide many services to ecosystems and their inhabitants:

- pest/disease control
- indication of environmental quality
- pharmaceuticals (for example, painkillers)
- subjects for a wide variety of research programs (even in outer space!)

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Gray treefrog (*Hyla versicolor*)

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- food (protein that is especially important in many developing countries)
- inspiration for religion, folklore, and the arts

What To Do?

The most evident threat to amphibians is habitat loss. Any effort to save native habitat will help all wildlife. Luckily, some amphibians will benefit from even the smallest efforts to save wetlands and forest remnants. Promoting a sustainable trade in amphibians and curbing the use of toxic chemicals, as well as greenhouse and ozone depleting gases, will provide further assistance. These efforts will increase the long-term productivity of forests and wetlands for human uses as well.

To help amphibians, we need to promote:

- enforced protection of ecosystems, especially forests and wetlands
- strict regulation of toxic chemicals, invasive alien species, and greenhouse and ozone-depleting gases
- inventory and monitoring of amphibian populations
- education on the ecological and cultural significance of amphibians
- sustainable use of amphibians and their habitats
- training of herpetologists (scientists who study amphibians)

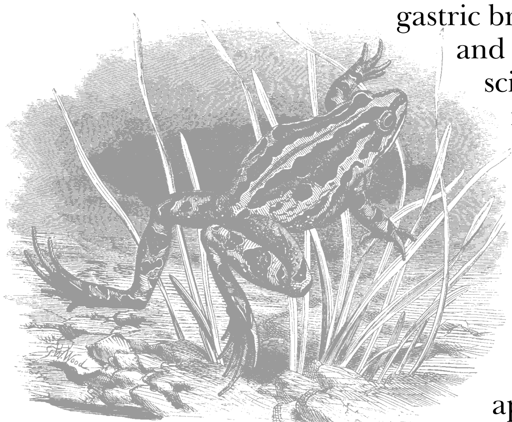
Overview

The Problem

- In the early 1900s a team of biologists surveyed amphibians along a transect running through the Sierra Nevada mountains, including Yosemite National Park. In the 1990s, biologists Charles Drost and Gary Fellers, then with the National Park Service, resurveyed the same line. Five of the seven frog and toad species had suffered severe declines. The foothill yellow-legged frog (*Rana boylii*) had completely disappeared from the area. The mountain yellow-legged frog (*R. muscosa*), once the most abundant species, consisted of only a few remaining populations.

- The golden toad (*Bufo periglenes*) of Costa Rica, so named because of the male's bright orange color, never failed to show up for its annual spring breeding orgy from the early 1970s through 1987. Dr. Martha Crump, then at the University of Florida, and her colleagues counted more than 1500 individual adult golden toads and a few tadpoles in 1987. In 1988 only 11 adults were found. A single adult male was last observed in 1989. Despite intensive searches, no golden toads have been seen since. The species is now believed extinct.

- In Australia, just north of Brisbane, a small frog was discovered in 1972. The gastric brooding frog (*Rheobatrachus silus*), so named because it swallowed and brooded its young in its stomach, was an immediate wonder to science. It was also a potential boon for physiologists interested in finding cures for ulcers and possibly other gastric disorders in humans. The frog has not been seen since 1981. There is little clue as to what caused its presumed extinction. It was found in relatively undisturbed tropical forest, far from routine human activity. The loss is of worldwide significance.



History

Concern for the apparent worldwide decline in amphibian populations was initially brought to the attention of the international community in 1989 at the First World Congress of Herpetology, held in England. At that meeting, participants presented scientific papers and exchanged personal accounts of amphibian declines and disappearances. Based on the infor-mation exchanged at this and subsequent meetings, amphibian researchers reached two major conclusions:

1) the number and the geographic extent of the informal reports indicate that the situation should be communicated and approached as a potential environmental crisis; and

2) an international working group should be established to determine the extent of the problem using scientifically defensible information. (See DAPTF page 13).

In the decade that has followed, the amphibian decline issue has indeed come to be regarded as an ecological emergency in progress. Population declines involving a large percentage of the amphibian community continue to be documented. Ranges of many species have been dra-matically reduced and species extinctions have occurred rapidly in some "protected" areas. Furthermore, amphibian popula-tions of multiple species around the world are experiencing a surge in bizarre and perplexing abnormalities.

The Causes of Decline

What is wrong with our planet? Could the thinning of the atmosphere's protective ozone layer be increasing exposure to ultraviolet radiation? Could this be a sign that global warming is in progress? Are diseases newly emerging or being transported further and faster? While many such questions have yet to be fully answered, a few "culprits" have been clearly identified:

Habitats: Cleared and Drained

The most evident threat to amphibians is the loss of forest and wetland habitats. Large herds of buffalo once created systems of wallows throughout the Great Plains, providing extensive surface water for amphibians. Beaver, the master wetlands engineers, once used their dam-building skills to create and maintain massive, complex wetland systems throughout much of the United States. Due to over-hunting and "pest control," buffalo and beaver are now gone from many regions, particularly the American West, and their former lands run dry.

Beaver (*Castor canadensis*)

Each year more forestland is cleared and additional wetlands are drained. Increasingly, the conversion is permanent; urban and suburban developments replace habitat with concrete and well-maintained lawns. The high levels of consumerism in the United States result in a seemingly insatiable hunger for land and water. Technological advances enable exploitation that is more rapid and extensive than at any time in history. Given the rapid rate and extensive scale of change, many amphibian species are unlikely to adapt and survive.

Trading Away Our Future

Some amphibians travel far from their native range. Increasing international demands result in the trade of amphibians as pets, food, medicine, research subjects, souvenirs, and even aphrodisiacs. While it has been well demonstrated that several amphibian species can be successfully raised in captivity, data on the U.S. import and export of amphibians suggest that many species are harvested from the wild by the hundreds to thousands annually. Because the population size and natural history of most amphibians are so poorly known, it is currently impossible to accurately determine their sustainable levels of use. For most regions of the world, the regulation and enforcement of the amphibian trade is weak or non-existent. Furthermore, large numbers of amphibians die under inhumane conditions when they are transported.

Poisoned

Because of their porous skin, amphibians may be particularly susceptible to chemical contamination. Wetlands are the repository for everything that runs downstream or washes downhill. The chemicals that drain off of roads can create a complex, toxic cocktail that includes such ingredients as gasoline, oil, and ice-melting agents. The rapid increases in human population size and consumer spending mean that more food must be produced for local use and export. The "modernization" of agriculture intensifies chemical use. Large amounts of various fertilizers and pesticides are added to the environment. These chemicals often are applied directly to amphibian habitats. However, they may also be transported by air or water and carried long distances, impacting amphibians far from the original point of contamination. Several of the chemicals used in the United States, known to be toxic to wildlife and threaten human health, have been banned for use by other countries.

Game Over

There is increasing evidence from around the world that where non-native predators such as fish, crayfish, and bullfrogs are introduced, amphibians often decline. These "invasive alien species" have been introduced outside their native ranges for commercial and recreational purposes, as food for other species, and as biological control agents for pests, many of which are also non-native species. A great diversity of these animals also have entered our waters through the hands of bored pet owners who release their captive pets, the purposeful stocking of warm waters by aquarists, the dumping of bait buckets, and as escapees from aquaculture facilities. Many of these invasives consume amphibians (adults, young, and eggs), and also compete with amphibians for insect prey. Invasive species can carry diseases and parasites, potentially spreading them to native amphibians.

Bullfrog (*Rana catesbeiana*)

Atmospheric Changes

As our atmosphere's protective ozone layer is depleted, damaging ultraviolet radiation (UV-B) from the sun reaches the earth in greater quantities. Ultraviolet radiation is, in part, what causes sunburn in people, and it can harm amphibians as well. UV-B damages DNA, a cell's source of genetic information. As a result, the cells mutate or die. Some species of amphibians create a product called photolyase that repairs this damage in time to save themselves, but many others cannot produce the chemical.

Since the early 1970s climatologists have projected a rapid increase in global temperatures. Changing weather patterns that result in drier conditions, alter the timing of the seasons, or lead to extremely hot and cold temperatures could threaten amphibians. If the current projections are accurate, global warming will have such an impact on many regions of the world. There is now evidence that the golden toad (*Bufo periglenes*) and several other species of frogs at Monteverde Cloud Forest Reserve in Costa Rica disappeared, at least in part, due to a shift in climate; the region is now warmer and drier than when the frogs thrived. In the United Kingdom global warming seems to be causing several species of frogs and newts to breed weeks earlier than they did twenty years ago. The newts used to breed after the frogs, but now breed earlier and devour frog eggs and tadpoles.

Sick and Dying

At several sites around the world where biologists have found multiple species of dead and dying amphibians, abnormal tadpoles, and/or dead egg masses, disease seems to be one of the culprits. When animals are stressed, their immune systems weaken, making them especially susceptible to infection by a wide variety of viruses, bacteria, and fungi. In most cases in which diseases impact amphibians, the originating stressors themselves are unknown. There is little information on the biology of most disease-causing organisms. In the search for the causes of amphibian declines, researchers continue to discover new amphibian diseases. Where they came from, by what means they attack, and how they are moved from one site to another have yet to be determined.

Implications For Society and the Environment

Amphibians warrant substantial conservation attention. To some they provide inspiration and natural services.

For others, they have become a profitable source of commercialization. Amphibians are considered valuable indicators of environmental quality, and concern that amphibian declines serve as a warning of threats to human health has invoked the attention of the public, research biologists, and policy makers.

D. Hardesty, USGS

Amphibians are not protected by fur, feathers, or scales. Chemicals and radiation readily penetrate their skin. Thus, they unwittingly sample what we add to the environment. Their population dynamics may therefore provide a reliable gauge of environmental quality. When the population size is large and young animals are regularly added to the population, the environment is likely in good health. However, when the number of individual amphibians decreases dramatically and young animals are not produced or die prematurely, biologists are inspired to investigate whether a decline in environmental health is responsible.

Because amphibians occupy both water and land habitats on all continents except Antarctica, they can provide us with geographically comparative information. The spatial extent of an amphibian population decline provides valuable insights as to the causative factors. For example, climate change would be expected to have a broad impact on wildlife populations, while a chemical spill might have very localized repercussions. By monitoring the dynamics of amphibian populations, we can identify and prioritize our responses to regions and habitats that seem to be declining in environmental quality.

Amphibians are the most diverse group of terrestrial vertebrates. The approximately 4,800 species currently described by science employ many different life history patterns. For example, some species are only aquatic, while others are only terrestrial. Some species spend the majority of their lives underground, and some species primarily are found high in the canopy of trees. Many species have aquatic larval forms that metamorphose into terrestrial adults, but some produce young that are tiny replicas of their parents. This great diversity provides yet another tool for evaluating environmental quality and for identifying factors that threaten ecological systems. For example, if the amphibians that are dying in a given area are mostly aquatic species, aquatic breeding species, and aquatic larval forms of terrestrial species, we would suspect that the factor(s) contributing to the decline in the amphibian community will be found in the freshwater systems. If the only species impacted are aquatic species that breed or have larval development in the spring, we might further suspect that the threats have a specific time component.

Amphibians have very important functions in the food chains of both aquatic and terrestrial systems. Amphibians consume aquatic

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Wandering garter snake (*Thamnophis elegans vagrans*) eating a Columbia spotted frog (*Rana luteiventris*)

vegetation, as well as invertebrates and other vertebrates. In the absence of fish, amphibians are usually the top predators in freshwater systems. However, amphibians are also prey to numerous predators, including snakes, fish, birds, mammals, spiders, and even each other. Consequently, amphibians influence the population dynamics of other organisms, as well as the cycling of nutrients and the flow of energy.

In some developing countries amphibians are an important source of the animal protein consumed by local people. Frogs are exploited as delicacies and aphrodisiacs in Europe, Asia, the United States, and many other countries. Amphibians, in finding novel ways to ward of predators and disease, have become living "chemical factories." The compounds they produce have inspired the development of some painkillers and antibiotics. Furthermore, amphibian products have had critical roles in advancing the treatment of wounds, certain cancers, such as small cell lung cancer, and gastrointestinal problems. Even the treatment of mental health disorders such as schizophrenia may benefit from compounds specific to amphibians.

Because many hunting poisons, ceremonial hallucinogens, and traditional drugs are amphibian products, and the calls of frogs often coincide with life-giving rains, amphibians are totems of luck for numerous native cultures. Frogs are model systems for laboratory research and instruction, as well as field studies that help explain the complexity of biological systems. Amphibians appeal to the human spirit, and provide inspiration for religion, folklore, and the arts, as well as corporate marketing campaigns. Due to their aesthetic appeal, amphibians have become increasingly popular in the pet trade.

The amphibian decline "crises" demand that the status of amphibian populations be assessed rapidly and that where declines are apparent, mechanisms be identified, habitats managed, and recovery programs established. This is much more easily stated than accomplished. Studies critical to understanding the population dynamics of amphibians are a challenge to support financially; scientific funding is usually provided for three-year cycles, but long-term research and monitoring often require ten or more years to complete. And, time is not on the side of the amphibians: human population and resource consumption continue to increase, rapidly changing the landscape in which amphibians have been evolving for roughly 350 million years.

The Charge

While the world's amphibian community has already suffered permanent losses, hope exists, at least for some species. At a few sites that experienced rapid declines, amphibian populations have rebounded or been re-established by colonizing individuals. Maintenance and recovery of environmental health, and the restoration of fragmented landscapes, will enable many amphibian species to persist. With the proper guidance, conservation

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organizations, societies of naturalists, and regional agencies can successfully establish local amphibian inventory and monitoring programs. Concerned citizens can join forces to restore private lands and to support government policies that protect and restore critical habitats. Environmental education programs can be developed to bring to light the many important roles that amphibians play in various societal and ecological contexts around the world.

The Players: Searching For and Implementing the Solutions

Declining Amphibian Populations Task Force (DAPTF)

An international investigatory team, the Declining Amphibian Populations Task Force operates under the umbrella of the World Conservation Union's Species Survival Commission. Formed in 1990, DAPTF employs a scientific approach to amphibian conservation; thousands of scientists volunteer their expertise to the program. The primary objectives of the DAPTF are to determine the geography, extent, and causes of declines and disappearances of amphibians.

Working groups coordinate the program's efforts across geographic regions and examine potential causes of amphibian declines, including toxins, UV-B radiation, and disease. DAPTF produces "Froglog," a newsletter primarily focused on working group updates and summaries of recent research findings. DAPTF supports research on amphibian declines through its "Seed Grant" program.

Partners in Amphibian and Reptile Conservation (PARC)

Partners in Amphibian and Reptile Conservation (PARC) was established in 1998 to facilitate communication and cooperation amongst government agencies, industry, academic institutions, funding institutions, hobbyists and the public. PARC is not a funding organization; rather, it is a network of individuals and organizations committed to working cooperatively to conserve amphibians, reptiles, and their habitats. Five working groups coordinate PARC activities: research, monitoring, management, education, and international policy.

Taskforce on Amphibian Declines and Deformities (TADD)

Formed in 1998, TADD is the United States' federal interagency response to the phenomena of amphibian declines and abnormalities. TADD's mission is to promote and coordinate federal agency activities for elucidating the causes of these problems and implementing the solutions. Four working groups (international, science, conservation, and education) coordinate taskforce activities.

Amphibian Conservation Alliance (ACA)

ACA is a nonprofit, science-driven education and advocacy organization established in 1997. ACA promotes the conservation and restoration of amphibian species and populations by supporting scientific research efforts related to amphibian conservation and restoration, and by facilitating the establishment and maintenance of an effective public constituency. ACA produces a newsletter entitled "Ribbetting News."

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Amphibians: Facts In Brief

Natural History

Horned frog (*Ceratophrys sp.*)

- **Three groups.** Amphibians consist of three major groups of animals: frogs (including toads and treefrogs), salamanders (including newts), and caecilians (little-known, worm-like creatures of the tropics).

- **Numbers.** Approximately 4,800 amphibian species have been described by science. The rate of species loss is immeasurable; we don't know how many amphibian species have come and gone without recognition.

- **"Dual lives."** The term amphibian is derived from Greek words (*ambi* and *bios*) that combine to mean dual life. Many amphibian species have an aquatic larval (tadpole) form that metamorphoses into a terrestrial adult form.

- **Long-term residents.** Amphibians evolved during the Devonian Era, and have survived approximately 350 millions years of climatic, geologic, and biological changes.

- **Adaptable.** Amphibians have the most diverse life histories of any terrestrial vertebrate. They have adapted to thrive not only in the most stable and resource rich environments, such as rainforests, but also in those most variable and hostile, including deserts where water may be limited to temporary pools of rain.

- **Abundant.** In some wetland and forest ecosystems, amphibians are the dominant vertebrate group in terms of total number of individuals and/or biomass (weight).

- **Permeable skin.** Amphibians transport water and air primarily through their skin rather than stomach and lungs. One group of salamanders (Plethodontidae) lacks lungs altogether. Regardless of life history pattern, amphibians remain obligated to moisture throughout their lives.

- **"Cold-blooded."** An amphibian's body temperature is strongly influenced by the temperature of its surrounding environment. In order to keep from becoming too hot or cold, an amphibian must change its body position, location, or employ a number of interesting physiological adaptations; for example, the wood frog, *Rana sylvatica*, produces a type of "anti-freeze."

- **Big families.** Most species of frogs which breed in ponds and other wetlands lay egg masses consisting of hundreds to thousands of eggs. In one instance, a single female bullfrog (*Rana catesbeieana*) laid 47,840 eggs in one gelantinous mass! Such big families are necessary to increase the likelihood that at least a few of the offspring will survive to adulthood.

- **Little Families.** Amphibians that primarily reproduce on land and in trees (water-filled cavities, epiphytes, etc.) tend to have small clutch sizes; some lay as few as a half-dozen eggs. In some of these species, parents guard their nests and young in order to better the chances of survival.

- **Long life potential.** Although the majority of amphibians will live only a few years, individuals of many species have the potential to live for one or more decades.

Major North American Amphibian Groups

A. Completely aquatic

1. Salamanders (for example, hellbender, mudpuppy, siren, amphiuma, neotenic[1] ambystomatid salamanders).
2. Frogs (for example, African clawed frog; introduced)

B. Lentic (still water) breeding/ semi-terrestrial adults

1. Salamanders (for example, ambystomatid salamanders, newts[2])
2. Frogs (for example, spotted frogs, wood frogs, treefrogs, toads)

C. Lotic (running water) breeding/ semi-terrestrial adults

1. Salamanders (for example, red and spring salamanders)
2. Frogs (for example, foothill yellow-legged frog, tailed frog)

D. Completely terrestrial

1. Salamanders (for example, red-backed salamander, slender salamanders)

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Two-lined salamander (*Eurycea bislineata*)

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Pacific treefrog (*Hyla regilla*)

[1]Animals reach sexual maturity but retain the larval form.

[2]The eastern red-spotted newt (*Notophthalmus viridescens*) has an aquatic larval form that metamorphoses into a terrestrial subadult form (red eft). When the newt reaches sexual maturity (3-7 years) it makes a few more changes (morphological and physiological) and returns to the water for the rest of its life.

Amphibians: Facts In Brief

Roles

Biological

Critical roles in providing Nature's services.

- **Consumers.** As larvae, many amphibians graze on plant matter and debris. As adults, most amphibians prey upon small invertebrates, such as insects, and other vertebrates. The giant toad (*Bufo marinus*) will opportunistically consume dog food and garbage. One species of tropical frog is known to eat fruit.

- **Prey.** Amphibians provide an important prey base for birds, mammals, fish, reptiles, insects, and spiders. Amphibians will even consume each other. Some species of bats and snakes consume only amphibians.

- **Efficient.** One study indicates that amphibians can be remarkably efficient at converting food for growth and energy. The red-backed salamander (*Plethodon cinereus*) has an efficiency rate of 95%, compared to 1-5% for humans.

Societal

Important sources of inspiration, players in health care and international economies.

- **Chemical factories.** Hunting poisons, ceremonial hallucinogens, and medical drugs have been derived from amphibians. Many painkillers and antibiotics were developed from amphibian products. Amphibians are currently employed in searches for cures to several major diseases.

- **Pest/disease control.** Amphibians consume large quantities of insects. By preying upon mosquitoes, amphibians may have critical roles in the control of diseases, such as malaria, especially in tropical countries.

- **International trade.** Amphibians are used throughout the world by culinary, biological supply, and pet markets.

- **Charismatic.** Amphibians provide inspiration for religion, folklore, the arts, and corporate marketing campaigns. Amphibians are totems of luck for numerous native cultures.

Status

- **Species extinctions.** Within the last two decades, entire amphibian species have mysteriously disappeared, most notably in Australia and Central America. Recent disappearances in the United States include the extinct Las Vegas Valley leopard frog[3] and the extirpated Tarahumara frog.[4]

- **Range reductions.** Due to documented rarity and severe reductions in range size, many species in the United States are now protected, or have been declared warranted for protection, under the federal Endangered Species Act.

- **Increased recognition of rarity.** Advanced molecular techniques are revealing that several broad-ranging species are actually complexes of multiple, similar-looking species. This means that many species are rarer and more vulnerable than previously thought.

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[3] The Las Vegas Valley Leopard frog (*Rana fisheri*) was likely always a rare species.

[4] The Tarahumara frog (*Rana tarahumarae*) is still abundant in parts of Mexico.

List of U.S. federally endangered and threatened amphibians*

	Endangered	Threatened
Salamanders	Barton Springs *(Eurycea sosorum)*	Cheat Mountain *(Plethodon nettingi)*
	Desert slender *(Batrachoseps aridus)*	Red Hills *(Phaeognathus hubrichti)*
	Santa Cruz long-toed *(Ambystoma macrodactylum croceum)*	San Marcos *(Eurycea nana)*
	Shenandoah *(Plethodon shenandoah)*	Flatwoods *(Ambystoma cingulatum)*
	Sonoran tiger *(Ambystoma tigrinum stebbinsi)*	
	Texas blind *(Typhlomolge rathbuni)*	
	California tiger *(Ambystoma californiense[5])*	
Frogs	Arroyo toad *(Bufo microscaphus californicus[6])*	Puerto Rican crested toad *(Peltophryne lemur)*
	Houston toad *(Bufo houstonensis)*	Guajon *(Eleutherodactylus cooki)*
	Wyoming toad *(Bufo hemiophrys baxteri)*	California red-legged *(Rana aurora draytonii)*
	Golden coqui *(Eleutherodactylus jasperi)*	

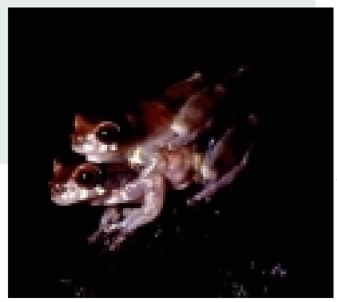
*Most of these species have geographically restricted ranges. Additional species await federal listing and numerous species and subspecies are on state endangered species lists.

- **Stability.** Amphibian population dynamics typically fluctuate and are often characterized as "boom and bust." For this reason, long-term (more than a decade) monitoring programs are required to determine whether amphibian populations are stable. Such monitoring programs exist at only a few sites in the world.

- **Range confusion.** Some amphibian species are relocated as game species or as a prey base for game species. This practice threatens native amphibians by introducing predators, competitors, and disease. Furthermore, it complicates our ability to assess the status of native amphibian populations.

Patterns Of Decline

- **Natural wetland loss.** In both urban and rural areas, amphibian range reductions correlate with the loss and degradation of natural wetlands.



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Treefrogs from South America (*Hyla brevifrons*)

- **Even protected areas.** Many of the recent, rapid population declines (and even some extinctions) have occurred in protected parks and wilderness areas.

- **Species introductions.** Throughout the world, amphibians are being lost at locations where game species (for example, fish and alien amphibians) have been introduced.

- **Ultimate factors.** Various pathogens (bacteria, fungi, fungal-like algae, and viruses) are often the ultimate causes of amphibian mortality. The specific stress factors that made these amphibians susceptible to disease are largely unknown.

[5] Santa Barbara Co. pop.

[6] May soon be reclassified as a distinct species, *Bufo californicus*

Causative Factors: State Of Knowledge

Habitat Loss

- **Permanent wetlands.** In the two centuries from 1780-1980, the lower 48 states lost an average of 54% of the estimated original 221 million acres of wetlands. Some states have been profoundly impacted; for example Iowa has lost approximately 95% of its wetlands. Small wetlands (< 0.2 ha) are being lost particularly fast. Furthermore, wetlands serve as deposition sites for numerous chemical, metal, and nutrient pollutants.

- **Ephemeral wetlands.** The temporary, small rain-filled vernal pools that many amphibians depend on for breeding are often eliminated for road grading, mosquito control, and "tidiness."

- **Forestry.** The practices of tree and deadfall removal make habitats unsuitable for many amphibians by increasing ground temperatures, reducing moisture, and eliminating refuge sites.

Habitat Fragmentation

- **Roads.** Many amphibians must travel long distances to and from breeding sites. Mortality due to automobile traffic can alter population dynamics and cause significant losses of both breeding adults and dispersing juveniles.

- **Drains/culverts.** In urban environments, amphibians can be trapped in roadside drains, culverts, and other open systems where they are drowned, starved, or swept into inappropriate habitat.

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Treefrog from Taiwan (*Rhacophorus* sp.)

- **Curbs.** Roadside curbs can act as barriers to dispersal, trapping amphibians in traffic-prone areas.

- **Chemistry.** Because amphibians have limited chemical tolerances, even small patches of pollutants or extreme pH can prevent amphibians from dispersing widely.

Introduced Species

- **Deadly game.** Amphibians can be eliminated when predacious game fish, crayfish, and bullfrogs are introduced to aquatic habitats. Fish introduced as bait and for mosquito control have also been shown to prey upon amphibian eggs and larvae.

- **Variable susceptibility.** Amphibians inhabiting the historically fishless aquatic systems of the western U.S. and high elevations nationwide are particularly vulnerable to introduced species. These amphibians may not have had the opportunity to evolve adequate chemical and behavioral defense mechanisms.

- **Disease transmission.** Many pathogens carried by introduced fish have the potential to infect amphibians, particularly if amphibians are under stress.

- **Increased isolation.** There is increasing evidence that some amphibians can chemically detect the presence of fish. Amphibians that avoid water inhabited by introduced fish become increasingly isolated in marginal, fragmented habitats.

Climate Change

- **Species extinctions.** There is now scientific evidence suggesting that the golden toad (*Bufo periglenes*) and several other species of frogs at Monteverde Cloud Forest Reserve in Costa Rica disappeared, at least in part, due to a shift in climate. The region is now warmer and drier than when the frogs thrived.

- **Breeding time.** In the United Kingdom five species of amphibians bred significantly earlier in 1990-1994 than they did in 1978-1982. All of the shifts in the timing of breeding correlated with changes in climate over the same period; winter and spring average temperatures are steadily increasing.

Ultraviolet Radiation (UV-B)

- **Species-specific mortality.** Laboratory and field experiments have demonstrated that species with low levels of DNA repair enzymes such as photolyase have embryos that are particularly susceptible to mortality via UV-B radiation.

- **Developmental abnormalities.** Laboratory research and field studies have revealed that the larvae of some species of amphibians may suffer abnormal development (for example, skeletal, eye and skin deformities) when exposed to typical and/or increased levels of UV-B radiation.

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White's treefrog (*Litoria caerulea*)

- **Damage.** UV-B radiation can cause retinal damage in the eyes of adult amphibians.

- **Geographic variation.** UV-B radiation is greatest at higher elevations and toward the polar regions. Deterioration of the ozone layer will increase the amount of UV-B reaching the Earth's surface.


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Great Basin spadefoot (*Spea intermontanus*)

- **Buffers.** Vegetation and cover objects, such as logs, can reduce the amount of UV-B reaching terrestrial amphibians. Some amphibians are behaviorally adapted to place their eggs in low UV-B microhabitats.

- **Synergisms.** UV-B can increase amphibians' susceptibility to diseases such as the pathogenic fungal-like algae *Saprolengia*. Low pH can exacerbate the negative impacts of UV-B radiation.

Contaminants

- **Deadly cocktails.** Laboratory studies demonstrate that, to varying degrees, amphibians are susceptible to compounds such as biocides, heavy metals, and petroleum products that often contaminate aquatic systems.

- **Aerial spraying.** Numerous chemicals, particularly those used in the agricultural industry, are dispersed from aircraft. This practice provides significant opportunity for the biocides to be carried by air currents and to contaminate non-target areas, including wetlands.

- **Endocrine connection.** Laboratory studies have shown that certain synthetic chemicals, including many biocides, can mimic or interfere with the action of naturally occurring hormones. Because of the critical role that hormones play in development, the negative impacts can be devastating. Research is currently underway to evaluate the role of these "estrogen disrupters" in the amphibian decline scenario.

- **Prey-base.** Many aquatic insects are susceptible to biocides. Amphibians are thus further at risk via a reduced and/or contaminated food supply.

- **Synergisms.** Low pH and UV-B can increase the toxicity of some contaminants. Stress due to contaminant toxicity likely increases amphibian susceptibility to disease.

Acidic Precipitation and Soil

- **Limited tolerance.** pHs below 4-5 can be lethal to the embryos and tadpoles of some amphibian species.

- **Influence on dispersal.** It has been demonstrated in the field that the presence of low pH substrates can limit the distribution of terrestrial and aquatic amphibians.

- **Prey base.** Low pH can cause high mortality of terrestrial and aquatic invertebrate fauna, amphibians' critical prey base.

- **Synergisms.** Laboratory and field studies have revealed that low pH can exacerbate the negative impacts of heavy metals, biocides, and UV-B on amphibians. Amphibians stressed by low pH may also be highly susceptible to disease.

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American toad (*Bufo americanus*)

Disease

- **Ultimate factors.** Pathogens (bacteria, fungi, viruses, and fungal-like algae) are often the ultimate causes of amphibian mortality. The stress factors that made these amphibians susceptible to disease are typically unknown.

- **Transmission.** Many pathogens carried by introduced fish have the potential to infect amphibians, particularly if amphibians are already under stress. Disease may also be spread by people, and by animals such as livestock, when they unwittingly transport aquatic debris and organisms from one wetland to another, and even across international borders.

Trade

- **Culinary.** Large frogs are particularly susceptible to the international trade in frog legs. This trade has been implicated as a factor contributing to the decline of the California red-legged frog (*Rana aurora draytonii*), the introduction of the predacious bullfrog to many parts of the world, and a surge in mosquito populations where native frogs populations have been decimated.

- **Aphrodisiacs/medicinal.** Many cultures, particularly in Asia, regard certain amphibians as having aphrodisiac and/or homeopathic qualities. The United States exports native amphibians to meet these demands.

- **Pet trade.** Due to their charisma and small size, amphibians are becoming increasingly popular in the pet trade. Although some individuals are captive-bred, most species are still primarily collected from wild populations.

- **Biological supply.** Most amphibians used as model systems for basic anatomy lessons and biological research are still collected from wild populations.

Amphibians: Facts In Brief

Amphibian Abnormalities

Status

- **Widespread.** Amphibian abnormalities have been reported in more than 50% of the United States, as well as in countries such as Canada, Peru, England, Germany, Japan, India, and Australia. At least thirty-three amphibian species have been involved.

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Pacific treefrog (*Hyla regilla*) with extra set of legs

- **Novel?** Abnormalities in amphibians, such as extra ("supernumerary") or missing limbs and/or digits, missing and/or damaged eyes, and incorrectly positioned appendages, are not new phenomena, and have been reported in the literature for more than two centuries. While some accounts report seemingly isolated incidences involving only a few individuals, others document problems impacting numerous animals of multiple species.

- **Trendiness.** Although the frequency of abnormal amphibian accounts has increased in the last few years, it should be noted that published reports of amphibian abnormalities have fluctuated in number since the early 1700s.

- **Lack of comparative data.** Unfortunately, long-term studies of amphibian population dynamics are rare and most museum collections are not sufficient to determine the "normal levels" of malformations. Based on a few recent field studies, some biologists consider malformations found in greater than 1% of the sampled population to be indicative of a problem.

- **Something out of the ordinary.** All caveats aside, there are a growing number of multi-year studies of amphibians that indicate malformations may be unusual and recent in parts of the U.S. and Canada.

Causative Factors

- **Multiple hypotheses.** A wide variety of factors have been implicated as causative agents of amphibian abnormalities, including parasite infestation, toxin contamination (for example, biocides, heavy metals, acidification), predation, UV-B radiation, radioactive salts, ground-level ozone, excessive heating of eggs, cosmic rays, and reformulated gasoline. Of these, only the parasite, toxin, UV-B, and predation hypotheses have supportive evidence.

- **Parasites.** Encysted trematodes have been isolated from Pacific treefrogs (*Hyla regilla*) with supernumerary limbs. When these trematodes are introduced to Pacific treefrog tadpoles in the laboratory, a significant percentage of the tadpoles develop limb abnormalities. Furthermore, the African clawed frog (*Xenopus laevis*) can be induced to develop such abnormalities when a resin ball (meant to mimic an encysted trematode) is inserted in a tadpole's region of limb bud development.

- **Toxins.** Many toxins have mutagenic effects on amphibians when administered in the laboratory. In Canada, a high incidence of abnormalities has been found in three species of frogs from agricultural sites exposed to toxins.

- **Predation.** Injury due to failed predation attempts and/or livestock trampling has been observed in Columbia spotted frogs (*Rana luteiventris*), western toads (*Bufo boreas*), and Pacific treefrogs (*Hyla regilla*), resulting in completely and/or partially missing limbs. In salamanders, such injuries can lead to the development of extra limbs/digits if errors occur during regeneration.

- **UV-B.** In laboratory and field experiments, UV-B radiation can induce skeletal, eye, and skin deformities in developing larvae.

Implications

- **Part of the decline scenario?** At a local scale, abnormalities may contribute to the decline of populations, but they are unlikely to explain the disappearance of species worldwide. Nonetheless, the issue of amphibian abnormalities is rightly poised within the discussion of amphibian declines for the following reasons:

(1) Abnormalities have the potential to result in high levels of amphibian mortality;

(2) Unraveling of the amphibian abnormality phenomena will likely assist us in understanding amphibian population dynamics, and thus strengthen our ability to tease apart human-induced problems and the mechanisms by which they operate;

(3) The issue of amphibian abnormalities is drawing the attention of the public and government officials to amphibians in general; and

(4) Abnormalities have been shown to impact some threatened and endangered species of declining amphibians.

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Southern toad (*Bufo terrestris*)

Resolution: Declining Amphibian Populations

This resolution was drafted by participants of a 28-29 May 1998 workshop on amphibian declines sponsored by the National Science Foundation, Washington, DC.

Whereas, there is compelling evidence that over the last 15 years there have been unusual and substantial declines in abundance and numbers of populations of various species of amphibians in globally distributed geographic regions, and

Whereas, many of the declines are in protected areas or other places not affected by obvious degradation of habitats, and

Whereas, these factors are symptomatic of a general decline in environmental quality, and

Whereas, even where amphibian populations persist, there are factors that may place them at risk, and

Whereas, some patterns of amphibian population decline appear to be linked by causative factors, and

Whereas, declines can occur on multiple scales, in different phases of amphibian life cycles, and can impact species with differing ecology and behavior, and

Whereas, there is no obvious single common cause of these declines, and

Whereas, amphibian declines, including species extinctions can be caused by multiple environmental factors, including habitat loss and alteration, global change, pathogens, parasites, various chemicals, ultraviolet radiation, invasive species, and stochastic events, and

Whereas, these factors may act alone, sequentially, or synergistically to impact amphibian populations, and

Whereas, to understand, mitigate, and preempt the impacts of these factors, a comprehensive, interdisciplinary research program must be undertaken, and

Whereas, this research program must be conducted in several regions around the globe, both in areas of known declines, and in areas where declines have not been documented, and

Whereas, this research must examine issues ranging from environmental quality of landscapes to the condition of individual animals,

NOW BE IT THEREFORE RESOLVED, the signatories hereto call for the establishment of an interdisciplinary and collaborative research program, which will specify and quantify the direct and indirect factors affecting amphibian population dynamics, and

Be it further resolved, that this program will include basic research and monitoring that will test hypotheses of causative factors and examine patterns of change through historical records, field-based correlative data, and controlled, multi-factorial experiments, and

Be it further resolved, that interdisciplinary, incident response teams should be assembled in “hot spots” of amphibian decline to identify causative factors to facilitate the mitigation of these sudden declines, and

Be it further resolved that the signatories hereto call upon both public and private agencies and institutions, to promote and support research, policies and conservation measures that will ameliorate losses and declines of amphibian populations, and

Be it further resolved that this broad-based approach to the study of amphibian population dynamics will serve as a model for study of the global biodiversity crisis.

Opportunities For Problem Resolution

Appropriations

- **Interdisciplinary.** Allocate funds for cooperative, interdisciplinary studies that seek to investigate multiple factors and unravel the complex mechanistic processes leading to amphibian declines.

- **Regional surveys.** Support regional surveys of amphibian population status and associated environmental factors, especially in areas for which comparative historical data are available.

- **Long-term.** Support monitoring programs that measure amphibian population dynamics and associated environmental factors for multiple years (preferably a decade or longer).

- **Multiple scale.** Although a small percentage of amphibian decline research is necessarily conducted with large budgets, extensive progress can be made if numerous low to moderately funded grants become available.

Regulatory

- **Habitat protection.** Promote, implement, and enforce policies that protect and restore aquatic and woodland ecosystems. Evaluate the effectiveness of wetland mitigation policies for amphibian conservation.

- **Biocide testing.** Develop and implement programs that 1) test commercial biocide formulas, rather than just active ingredients; 2) test biocide formulas under "natural" conditions; 3) require evaluation of native amphibian species of varying life histories; and 4) identify models of susceptibility across species and life history stages.

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- **Biocide regulation.** Assess effective policies and procedures of countries (for example, Australia) that are banning biocides because of their negative impacts on amphibians. Re-evaluate U.S. policies on biocide exportation in cases where biocides are already known to have a negative impact on wildlife.

- **Species introductions.** Develop, implement, and enforce policies that are extremely cautious with respect to fish and amphibian introductions, have austere penalties for unauthorized introductions, and require restoration of impacted ecosystems.

- **International trade.** Assess U.S. importation and exportation of amphibians by region and species. Evaluate impact of harvest on populations within regions of origin. Develop, implement, and enforce harvest policies that sustain native populations of amphibians and require their humane treatment.

Amphibians: Facts In Brief

AN EFFECTIVE RESEARCH STRATEGY:

Is INTERNATIONAL in scope; COOPERATIVE across disciplines and geographic regions; IDENTIFIES information needs (localities, biological understanding) and PRIORITIZES them; INVESTIGATES both process and pattern in habitats, individual animals, and populations; utilizes MULTIPLE APPROACHES (for example, diagnostic and case study); INTEGRATES top-down and bottom-up studies (i.e., landscape to molecular); and PROVIDES GUIDELINES for inventorying, monitoring, and management.

- **National Environmental Policy Act (NEPA).** Utilize the NEPA process to analyze federal impacts on amphibian populations.

Research

- **Strategic planning.** Develop and implement a strategic investigatory approach to diagnosing the causes and consequences of amphibian declines.

- **Rapid assessment.** Design a rapid assessment approach and designate regional rapid assessment coordinators for evaluating dramatic amphibian die-offs in progress.

- **Standardization.** Utilize and report on a standard sampling/research protocols in order to make findings comparable.

- **Stressors.** Develop and implement research programs that examine the most likely stress agents.

Monitoring

- **Standardization.** In order to make findings comparable, utilize previously published standard sampling protocols and specify them in reports (see reference section for standard technique guides).

- **Historical comparisons.** Identify and prioritize sites for which there are good historical data; accounts should be verifiable and site specific.

- **Long-term.** Design and implement monitoring programs that can be carried out and are comparable across multiple years, preferably a decade or longer.

- **Multi-variable.** Design and implement comprehensive programs that collect adequate data on multiple species of varying life histories, as well as factors which might threaten them.

Management

- **A lands perspective.** Develop and implement a program for managing amphibian populations on federal lands, and in cooperation with private and state landowners.

- **Adaptive.** Develop and implement strategies using current knowledge of biological patterns and processes. Re-evaluate and improve management strategies as new information becomes available.

- **Risky business.** Develop and implement a strategy for assessing the risk of anthropogenic activities to amphibians of varying life histories and life stages. Incorporate this strategy into environmental impact assessments.

- **Getting into the game.** Assess the impact of game management on amphibian species and identify opportunities for enhancing amphibian management via game management programs, such as those employed for native trout.

Communication

- **Say it like it is.** Express the grand challenge of conserving populations, species, and ecosystems in an environment where stress factors act synergistically and systemic disruptions can have cascading impacts. This serves to appropriately illustrate the interconnectedness of biological systems.

- **Case studies.** Develop and promote a story approach to explain the complex scenario of amphibian declines.

- **So what?** Stress the consequences of amphibian loss and what the pattern of amphibian loss may signify, particularly for human well-being.

- **Poster larvae.** Develop a strategy/campaign for using the amphibian decline issue as a means to draw attention to and explain the causes and consequence of the general biodiversity crises. Illustrate that these animals have been around for approximately 350 million years and thus have evolved great capacities for survival, yet are now declining rapidly.

- **Stakeholder analyses.** Identify specifically what information, in what form, and on what timeline policy makers, educators, etc., need in updates from the scientific community. Develop a strategy for bringing science into the service of society in a timely and effective manner.

- **Not by science alone.** Emphasize that science in and of itself cannot solve the amphibian decline crises. It will be solved by placing scientific findings in the extended hands of people who have the capacity to make change happen.

Training

- **Needs assessment.** Determine the necessary skills and knowledge required to conduct basic research on, manage, and monitor amphibians. Evaluate the knowledge and skill base of field-based personnel charged with these tasks.

- **Expand target audience.** Encourage the participation of biologists from other field-based science and management practices. In addition, evaluate the potential of utilizing a volunteer naturalist workforce for specific tasks and projects.

- **Transfer tools.** Develop and implement training courses that fulfill the needs of the target audience in a timely manner.

- **Ongoing support.** Evaluate the utility of existing materials, including booklets, fact sheets, reports, videos. Develop and disseminate materials and mechanisms such as topical short courses or advisory networks to the target audience.

Resources

Publications

Froglog. Newsletter of the Declining Amphibian Populations Task Force (DAPTF). Write to John W. Wilkinson, Department of Biology, The Open University, Walton Hall, Milton Keynes, MK7 6AA, United Kingdom or find on the World Wide Web at:
http://www.open.ac.uk/OU/Academic/biology/J_Baker/JBtxt.htm

Ribbetting News. Write Amphibian Conservation Alliance (ACA), 563 Main Street, Oakland, CA 94609-1568, or call (510) 653-6006. This quarterly newsletter is free to all ACA members and donors.

Web sites

Amphibia Web
http://www.amphibiaweb.org

ACA (Amphibian Conservation Alliance)
http://www.frogs.org

CARCN (Canadian Amphibian and Reptile Conservation Network)
http://www.cciw.ca/ecowatch/dapcan

DAPTF (Declining Amphibian Populations Task Force)
http://www.open.ac.uk/OU/Academic/biology/J_Baker/JBtxt.htm

FrogWeb
http://www.frogweb.gov/

The Froggy Page
http://frog.simplenet.com/froggy/

NAAMP (North American Amphibian Monitoring Program)
http://www.im.nbs.gov/amphibs.html

NARCAM (North American Reporting Center for Amphibian Malformations)
http://www.npwrc.usgs.gov/narcam

PARC (Partners in Amphibian and Reptile Conservation)
http://www.parcplace.org

TADD (Taskforce on Amphibian Declines and Deformities)
http://www.frogweb.gov

Recommended Reading

Amphibian Declines

Green, D. M. (ed.) 1997. Amphibians in Decline: Canadian Studies of a Global Problem. Society for the Study of Amphibians and Reptiles, Herpetological Conservation, Number One.

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Zim, H. S. and H. M. Smith. 1987. Reptiles and Amphibians. Golden Press, New York.

Audio Tapes

Sounds of North American Frogs by Charles Bogert
Smithsonian Folkways
Center for Smithsonian Folklife and Cultural Studies
955 L'Enfant Plaza
Suite 7300, MRC 953
Smithsonian Institution
Washington, DC 20560

Frog and Toad Calls of the Pacific Northwest by Carlos Davidson
Frog and Toad Calls of the Rocky Mountains by Carlos Davidson
Library of Natural Sounds
Cornell Lab of Ornithology
159 Sapsucker Woods Road
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It’s too much for a child to know: while we sit
here on the back porch, talking,
the last glass frog on earth could be singing
somewhere in the cloud forest,
lime-green jewel in the night, our own grief
entangled in its vanishing cadenza.

-- from “The Silence of the Frogs”
by Susan Rea Katz

By Jamie K. Reaser
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