AMPHIBIAN & REPTILE
CONSERVATION
THE INTERNATIONAL JOURNAL DEVOTED TO THE WORLDWIDE PRESERVATION AND MANAGEMENT OF AMPHIBIAN AND REPTILIAN DIVERSITY

Volume 1, No. 1, Fall 1996

Printed on recycled paper with soy based ink

On the Cover

A male Golden toad *(Bufo periglenes)* at the Monteverde Cloud Forest Reserve, Costa Rica. Sadly, there have been no confirmed sightings of Golden toads seen since May of 1989, when a single male was seen. No one knows why this species disappeared from its pristine forest surroundings, far from human activities.

Golden toad photographs generously donated by Michael and Patricia Fogden, Natural History Photographers, Kinbuck, Dunblane, Perthshire FK15 9JU, Scotland, UK. Tel/fax: +44 1786 822069.

Contents

Next Issue

Conservation of South African's Endemic Dwarf Chameleons

Scope: *Amphibian & Reptile Conservation (ISSN 1083-446X)* is an international peer reviewed journal devoted to the worldwide preservation and management of amphibian and reptilian diversity. Audience: *Amphibian & Reptile Conservation* is intended for a wide readership from the amateur to the professional and is therefore written with abstracts, explanatory text, full references, ample photographs, tables, figures, diagrams, and other illustrations to help elucidate the text. Focus: *Amphibian & Reptile Conservation* concentrates on publishing timely information in the form of feature articles, reviews, reports, short communications, columns, commentaries, book reviews, and news and notes. Frequency: *Amphibian & Reptile Conservation* is published quarterly in the spring, summer, fall, and winter. Publisher: Amphibian & Reptile Conservation, 2255 North University Parkway No. 15, Provo, Utah 84604-7506 USA. Subscriptions: Annual subscription rate categories are individual subscription $18.00 (US) and institutional $36.00 including postage. All subscriptions outside the United States include $7.00 for shipping (individual $25 and institutional $43). *Amphibian & Reptile Conservation* is distributed to every country in the world (subscribers worldwide) and delivery is guaranteed. Contributions: Contributions to the journal are accepted. These resources are used to further the conservation efforts of reptiles and amphibians and the goals of the journal. Categories include friends of *ARC* $40, supporting $50, contributing $100, patron $250, sustaining $500 and founder (includes lifetime subscription to *Amphibian & Reptile Conservation*) $1,000. All other contributors receive four issues of *Amphibian & Reptile Conservation*. Back Issues: Back issues are available from the publisher for $8 each. The premiere issue can be purchased for $10. Payment: All journal orders must be prepaid in US currency drawn on a US bank or with an international money order. Communications: It is recommended that all correspondence be conducted via electronic mail (e-mail) whenever possible. All other correspondence should be directed to *Amphibian & Reptile Conservation, 2255 North University Parkway No. 15, Provo, Utah 84604-7506 USA*. E-mail: ARC@byu.edu. URL:http://www.byu.edu/~arcon/ Postmaster: Please send change of address to publisher (*Amphibian & Reptile Conservation, 2255 North University Parkway No. 15, Provo, Utah 84604-7506 USA*) six weeks prior to move. Production: Manufactured and printed in the United States of America.

Figure 1. Nine male Golden toads *(Bufo periglenes)* at a breeding pool, Monteverde Cloud Forest, Costa Rica. Photo generously donated by Michael and Patricia Fogden.

Amphibian & Reptile Conservation (Fall 1996), 1(1): 4-9

The Elucidation of Amphibian Declines

Are Amphibian Populations Disappearing?

Jamie K. Reaser
Center for Conservation Biology, Department of Biological Sciences, Stanford University, Stanford, California 94305-1901

Key Words
Population declines, extinction, conservation, research, monitoring, amphibians

Abstract
Information regarding most amphibian declines is anecdotal and natural fluctuations in amphibian population size are not uncommon. However, biologists can no longer find amphibians in regions where they were once numerous, and have directly observed population declines and species extinction. Inventory and monitoring programs are being established worldwide in order to assess the status of amphibian populations and to attempt to identify causes of declines. Factors that may be contributing to local amphibian declines include natural population fluctuations, natural succession and other changes in vegetation, introduced predators and competitors, pathogens, excessive collecting, toxic compounds, and habitat destruction. Climate disturbance, pollutants, and increases in UV-B radiation have been implicated in some well documented regional amphibian losses. These factors may decrease amphibian population size by causing mass mortality, reducing the ability of individuals to produce viable offspring, and/or by inhibiting dispersal of individuals. A loss of amphibians will have a significant impact on the state of the environment, as well as a decline in our cultural heritage and human well-being. Both biologists and concerned citizens have vital roles in amphibian conservation. A brief list of possible citizen actions to help protect amphibious life is presented here.

Correspondence, tel: (415) 725-9915, fax: (415) 723-5920, e-mail: jkrtoad@leland.Stanford.edu

Amphibian populations worldwide seem to be declining. Even the causal observer can not find frogs, toads, and other amphibians as numerously as they once could. Within the few short decades of our lifetimes, a wide variety of amphibians seem to have been disappearing. Population declines and species extinction dot the pages of personal journals. Biologists now search harder than ever, asking "why" and hoping to find the answers so that future generations don't have to be told what they are missing.

Finding answers is no easier than finding frogs. There is ample evidence that humankind has greatly impacted the distribution and abundance of animal and plant species worldwide through extensive habitat alteration and degradation. Such observations can be made daily, and by non-biologists. What we need to know, however, is how specific land uses impact the population dynamics of amphibians, and at what spatial and temporal scales. We also need to know what the loss of amphibians means for the continued functioning of ecosystems. Ultimately, we need to know what the disappearance of amphibians signifies for human well-being.

The paucity of data

Unfortunately, information regarding most amphibian declines is anecdotal. For several species, range reductions are well documented, but local population declines are less evident. For most species, studies only provide fragmentary pictures of populations on population trends.

Research on amphibian ecology has historically lagged behind that of other vertebrate groups because amphibians are often difficult to study and funding is harder to obtain. Those concerned about the loss of Neotropical migratory birds can reference broad ranging, standardized datasets from numerous monitoring programs. Several of these datasets span multiple decades; one was initiated as early as 1900. However, long-term (decade or longer) monitoring programs exist for only a few amphibian species and only at specific sites. Amphibian population dynamics can typically be described as "boom or bust;" natural fluctuations may be the rule rather than the exception. Thus, only very long-term datasets are useful in validating suspected trends and elucidating the mechanisms of amphibian population declines.

The first worldwide effort to assimilate data and hypothesize the causes and consequences of amphibian declines was held in Irvine, California in 1990 (Blaustein and Wake 1990). Since this meeting, an international investigatory team, entitled the Declining Amphibian Populations Task Force (DAPTF) of the Species Survival Commission (SSC), International Union for the Conservation of Nature (IUCN), has been formed and working groups have been designated to address potential causes (*e.g.*, toxins, UV-B radiation, pathogens) and geographic regions. The findings of working groups and individual scientists are published quarterly in the DAPTF newsletter, *Froglog*, making information readily available. Conservation organizations, naturalist societies, and regional agencies have been successful in establishing local amphibian inventory and monitoring programs that often effectively utilize a massive volunteer work force. County- and continent-wide initiatives, such as the North American Amphibian Monitoring Program (NAAMP), are in various stages of design, testing, and implementation.

What we do know

Amphibian populations can fluctuate greatly between years; variations in moisture, predation, competition, disease, and catastrophic events may greatly influence population size. Populations may suffer great losses. Yet, if the same populations experience "good years" that result in many surviving offspring, the long-term population trend may be stable. Long-term stability may also be attained if amphibians from other locations recolonize sites where populations have been annihilated. For example, Norman Weitzel and Howard Panik observed Pacific chorus frogs *(Pseudacris regilla)* in Nevada and found that in 80% of the years between 1975 and 1989 frogs produced offspring that became members of the next generation. The population was annihilated from the breeding pond ten times by natural disturbances that included flash floods, stream dry-ups, and sudden increases in water temperature. Yet, after each local extinction event, this population was soon reestablished by colonizing chorus frogs.

Extremely long-term datasets are required to distinguish between natural population fluctuations and anthropogenically induced declines. Joseph Pechmann and his colleagues monitored populations of one species of frog and three species of aquatic-breeding salamanders in the southeastern U.S. for twelve consecutive years. They found no evidence of drastic declines for any species, although the populations sizes did fluctuate. However, biologists Michael Reed and Andrew Blaustein recently reanalyzed Pechmann's data as well as that from four other long-term studies using a statistical tool called power analysis. All these studies, analyzed by this method, indicated no declines. While the datasets from these studies were not extensive enough to reveal statistical evidence of a decline, the lack of decline in populations of these amphibians could not be supported. Thus, even with twelve years worth of scientifically rigorous data, the status of these amphibian populations cannot be definitively assessed.

Amphibians cannot be found in many of the locations where they were once numerous. Yellow-legged frogs, red-legged frogs, spotted frogs, leopard frogs, western toads, cricket frogs, and tiger salamanders are a few of the North American amphibians dwindling in the number of sites of occurrence and population size. The amphibian queue for listing under the United States' federal Endangered Species Act has become so long that species ruled as justified for protection are precluded from it for years by stacks of preceding paperwork.

Herpetologists have witnessed the vanishing of amphibian populations, and even entire species. Biologists Stephen Corn and James Fogleman conducted an exceptional study, documenting six populations of the leopard frog *(Rana pipiens)* in Colorado for the decade 1973-1982. In 1973 only a single population failed to reproduce. For frogs this may not be unusual, but by 1981 no leopard frogs could be found at any of the sites. The study ended with a total absence of *R. pipiens* in the region.

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 (see Figure 1, page 4) from the early 1970s through 1987. Martha Crump and her colleagues counted 1500 individual adult golden toads in 1987, but noted that only 29 tadpoles metamorphosed and joined the population. From 1988 to 1990 these biologists located only 11 toads. *Bufo periglenes* has not been seen at the study site since.

In Australia, just north of Brisbane, a bizarre little frog was discovered in 1973. The gastric brooding frog *(Rheobatrachus silus)*, so named because it swallowed and brooded its young in its stomach, was an immediate wonder to science and a potential boon for physiologists interested in finding cures for ulcers and possibly other gastric disorders in humans. A loss of worldwide significance, the frog has not been seen since 1979, leaving little clue as to what caused its extinction. Strangely enough, its natural habitat was found in seemingly pristine tropical forest, far from routine human disturbance.

Why are amphibians declining?

Could the above mentioned frogs have succumbed to natural, localized climatic disturbances such as drought ... been the victims of opportunistic pathogens ... suffered from a yet, undetected global atmospheric phenomenon? Could the little known golden toad and gastric brooding frog merely be sitting it out underground, awaiting what they consider more favorable conditions?

It is difficult to generalize as to the causes of amphibian disappearances. Not every amphibian population, nor every species, is declining. And, those that are declining are doing so at varying rates and scales. Figuring out what is happening to amphibians and why is exasperatingly difficult and exhaustingly time consuming.

Locally, factors that may be contributing to amphibian declines include natural population fluctuations, natural succession and other changes in vegetation, introduced predators and competitors, pathogens, excessive collecting, toxic compounds, and habitat destruction. Climate disturbance, pollutants (particularly those associated with acid deposition and pesticides), and increases in UV-B radiation have been implicated in some well documented regional amphibian losses (see reviews by Barinaga 1990; Wyman 1990; Blaustein and Wake 1990; Tyler 1991; Phillips 1994; Blaustein and Wake 1995).

Unfortunately, there may be a significant time lag between the negative influence of a factor on amphibians and evidence of a population decline. Prospecting for cause and effect relationships is, therefore, exceptionally difficult even in contemporary studies. Diagnosis is further complicated because factors can act in concert and their relationship is rarely obvious. For example, frogs have been observed to die of an infection caused by a common, widespread microbe called *Aeromonas hydrophilla* that is not normally pathogenic. Any number of other factors may inhibit frogs' immune systems, making them susceptible to infection.

Three general hypotheses illustrate the mechanisms by which various factors can cause the extinction of amphibian populations, and eventually species:

1) Mass Mortality hypothesis

A factor or combination of factors influences amphibians in such a manner as to induce mortality of individuals, sometimes entire populations. Different factors may contribute to mortality at varying points in amphibian development. However, the decline of many populations is not merely a problem of producing viable offspring. It is apparent that some factors are influencing adult survivorship because many of the rapid declines are occurring in periods far shorter than the animals' life span.

2) Reduction of Fitness hypothesis

One or more sublethal factor(s) reduces the ability of individual amphibians to produce viable offspring (*i.e.*, "fitness"). This eventually leads to population declines and even population- and species-level extinction. Genetic variation, growth rate, size at maturity, longevity, and physiological constraints all influence the fitness of amphibians. Some amphibians have such specific conditions for breeding that even subtle environmental changes can result in the failure of a population to breed.

3) Failure to Rescue hypothesis

The observed declines are primarily driven by the failure to reestablish populations following local extinction. Typically, when a local population goes extinct, the habitat is colonized by amphibians dispersing from nearby sources (this reestablishment is termed the "rescue effect"). Under this scenario, changes in the chemical or structural environment prevent amphibians from dispersing widely.

Several biological characteristics of amphibians are likely to impede recolonization following local extinction: (1) physiological limitations (particularly water requirements) make it difficult, even impossible, for amphibians to persist in or travel through suboptimal habitat; (2) amphibians tend to have small home ranges, many move only short distances, and rarely "wander"; and (3) amphibians, especially the adults of many species are extremely faithful to a specific location, or set of locations, and are unlikely to abandon sites even if they can no longer breed there.

The specific means (*e.g.*, physiological processes) by which these general mechanisms operate are not well understood and are rarely investigated. In part, this is due to the fact that solving the puzzle requires the cooperation of experts across disciplines as diverse as geology and genetics. Regretfully, most biologists are highly specialized and rarely trained or encouraged to work with colleagues from other fields. When they have, however, pieces of the puzzle fall into place. For example, and interdisciplinary team in Oregon led by Andrew Blaustein is now able to illustrate how stratospheric ozone depletion may lead to amphibian population decline. It works like this: Ultraviolet-b radiation penetrates the Earth's thinning, protective ozone shield and beams its way to earth where it comes in contact with amphibian eggs. The high-level and/or prolonged exposure to radiation causes damage to eggs' DNA (the genetic information template) molecules, which in turn results in the death of cells and thus tadpoles do not develop. As adult frogs die and are not replaced by new generations, the population declines and eventually goes extinct. Blaustein and the other investigators further learned that different amphibian species have varying amounts of photolase, an enzyme that can repair DNA damage. The declining Cascades frog is low in photolase, while the coexisting and successful Pacific chorus frog has good DNA repair capabilities; extra copies of photolase genes secure protection.

The impact of amphibian declines

A loss of amphibians will have a significant impact on the state of the environment. Amphibians are vital components of the world's ecosystems. Amphibians comprise one-quarter of all vertebrate species on earth and sometimes constitute the highest percentage of vertebrate biomass in a given area. This measure may be positively correlated with a species' contribution to ecosystem function; *i.e.*, it is one indication of the organisms' importance to maintaining the system's integrity. Amphibians consume aquatic vegetation, invertebrates and other vertebrates, and are eaten by numerous predators. Therefore, amphibians play multiple, vital roles in the food chain of ecosystems.

Amphibians are apparently declining even in seemingly pristine, protected areas worldwide. Because of these trends, many biologists are pondering whether amphibian declines should be interpreted as a warning signal; that is to say that the disappearance of amphibians indicates that something is gravely amiss in the biosphere. Because amphibians have permeable gills, skin, and eggs; have diverse life histories; are widely distributed and occupy a variety of habitats, their population dynamics may qualify as reliable gauges of environmental health (if only we can learn to interpret the signals).

Frogs are totems of luck for numerous native culture; many hunting poisons, ceremonial hallucinogens, and medicinal drugs are amphibian products. Amphibians are chemical factories and the compounds they produce may hold cures to all sorts of ills, including AIDS and cancer. If you've had painkillers administered recently, you may have a frog or two to thank. For an excellent review of amphibian contributions to medicine, see Grenard's (1994) *Medical Herpetology*.

You can make a difference

Approximately 5,000 amphibians have been described by science, with additional descriptions being cataloged at a rate of 1 to 2 percent a year. The rate of loss is immeasurable; we don't know how many amphibians have come and gone without recognition.

The amphibian decline "crises" demands that the status of amphibian populations be rapidly assessed and that where declines are apparent, mechanisms be identified, managed, and recovery programs established. This is much more easily stated than accomplished. There are far more amphibians than biologists investigating their declines. Funding is hard to come by, particularly for the long-term studies that are critical to understanding amphibian population dynamics. Also, time is not on the side of the amphibian population dynamics—human population and resource consumption continue to increase, rapidly changing the landscape that amphibians have been evolving in for roughly 350 million years.

Yes, there is hope. Amphibian populations have rebounded and sites have been recolonized following massive die-offs. Maintenance and recovery of environmental quality, and the restoration of fragmented landscapes will enable amphibians to persist.

As a citizen concerned about amphibians, your role in amphibian conservation is as critical as that of any highly trained biologist. The following is a very brief list of the many actions that you can take to help protect amphibians, and maintain their vital roles in the circle of life.

• Become a volunteer assistant for a local amphibian monitoring program or research project. Contact your regional wildlife agency for information on studies in your area.

• Enlighten other people to the wonders and plight of amphibians by harnessing your enthusiasm and knowledge. Talk to children, the media, local officials, and the voting public.

• Support legislation that promotes healthy, intact ecosystems.

• Fight legislation that weakens control of pollution and land development.

• Encourage government agencies to fund long-term research projects on amphibians.

• Respect your wetlands by keeping them healthy. Do not pollute them with unnatural refuse such as litter and harmful chemicals (*e.g.*, petroleum products and pesticides).

• Organize routine cleanup projects.

• Admire amphibians in the wild; don't keep them as pets (animals kept for research, in legitimate conservation breeding projects, and as educational displays such as in zoological parks and aquariums are not considered pets and contribute to the conservation of species).

By joining forces, biologists and concerned citizens around the world can become a very powerful lobby for the conservation of amphibians. And amphibians, inventoried and monitored by these people, may be a powerful gauge for ensuring the protection of all life.

References

Barinaga, M. 1990. Where have all the froggies gone? *Science* 24: 1033-1034.

Blaustein, A.R. 1994. UV repair and resistance to solar UV-B in amphibian eggs: A link to population declines? *Proceedings of the National Academy of Sciences (USA)* 91: 1791-1795.

Blaustein, A.R. and Wake, D.B. 1990. Declining amphibian populations: A global phenomenon? *Trends in Ecology and Evolution* 5: 7.

Blaustein, A.R. and Wake, D.B. 1995. The puzzle of declining amphibian populations. *Scientific American* 272(4): 52-57.

Corn, P.S. and Fogleman, J.C. 1984. Extinction of montane populations of the northern leopard from *(Rana pipiens)* in Colorado. *Journal of Herpetology* 18: 147-152.

Crump, M.L., Hensley, F.R., and Clark, K.L. 1992. Decline of the golden toad: Underground or extinct? *Copeia* 1992: 413-420.

Grenard, S. 1994. *Medical Herpetology*. Reptile and Amphibian Magazine, Pottsville, Pennsylvania. 139 pp.

Pechmann, J.H.K. and Wilbur, H.M. 1994. Putting declining amphibian populations in perspective: Natural fluctuation and human impacts. *Herpetologica* 50: 65-84.

Pechmann, J.H.K., Scott, D.E., Semlitsch, R.D., Caldwell, J.P., Vitt, L.J., and Gibbons, J.W. 1991. Declining amphibian populations: The problem of separating human impacts from natural fluctuations. *Science* 253: 892-895.

Phillips, K. 1994. *Tracking the Vanishing Amphibians*. St. Martin's Press, New York. 244 pp.

Reed, J.M. and Blaustein, A.R. 1995. Assessment of "non-declining" amphibian populations using power analysis. *Conservation Biology*. In Press.

Tyler, M.J. 1991. Declining amphibian populations—a global phenomenon? An Australian perspective. *Altyes* 9: 43-50.

Weitzel, N.H. and Panik, H.R. 1993. Long-term fluctuations of an isolated population of the Pacific chorus frog *(Pseudacris regilla)* in northwestern Nevada. *Great Basin Naturalist* 53: 379-384.

Wyman, R.L. 1990. What's happening to the amphibians? *Conservation Biology* 4: 350-352.

While the Bird Conservation Specialist for the Smithsonian Institution's Migratory Bird Center, Jamie K. Reaser coauthored her first book, Bring Back The Birds: What You Can Do To Save Threatened Species *(Stackpole Press 1995). In 1993 Dr. Paul Ehrlich, presented Jamie with the opportunity to pursue her interest in amphibians through formal investigation as his doctoral student at Stanford University. Both Jamie and Dr. Paul Ehrlich are interested in what amphibian population trends might indicate about the health status of the biosphere.*

One of Jamie's greatest rewards of her work with amphibians is the opportunity to mentor undergraduate students who are interested in amphibian ecology and conservation. An open invitation is extended to those interested to visit her at Stanford University.