Declining Amphibian Populations: A Global Phenomenon?

Andrew R. Blaustein and David B. Wake

AMPHIBIAN POPULATIONS ARE DWINDLING in many parts of the world. Disappearances of frogs, toads and salamanders have been reported in areas of North America, Central and South America, Europe, Asia, Africa and Australia. Habitat destruction by humans accounts for some of the decline, but biologists are alarmed and perplexed by extinctions in areas seemingly protected from human influence.

Thus, it was with some urgency that a workshop sponsored by the National Research Council (USA) was held in February at Irvine, California, to assess the increasing evidence that around the world amphibian numbers are declining. Scientists from many countries presented data on population trends in amphibians from their own research, and provided evidence that both population sizes and geographical ranges are diminishing for many species. The workshop participants scrutinized this evidence, speculated on the possible causes of the declines, and assessed the impact of a potential world-wide reduction of amphibians.

The fact that amphibian populations – like others – generally fluctuate was succinctly brought out by Henry Wilbur of Duke University, North Carolina. Stochastic processes that contribute to natural extinctions and colonizations occur in all communities[1,2], and natural fluctuations – especially in marginal habitats – may explain some of the local extinctions. For example, this could account for the loss of local populations of the chorus frog (*Pseudacris triseriata*), which lives in small pools on Isle Royale, Michigan, reported by David Smith of Williams College, Massachusetts. However, natural stochastic events are difficult to invoke as explanations for the world-wide decline of an entire class of animals, which seems to have begun, for many species, in the early to mid 1970s.

Although each set of data documenting a local extinction is not overwhelming by itself, it is the accumulation of evidence from across the world that points toward a global decline. Relatively good population and geographical records have been kept for years for several species of frogs and toads that inhabit relatively pristine areas of western North America. The decline in populations and shrinkage in geographical range of several of these species exemplify the types of decline that are apparently occurring throughout the world.

Andrew Blaustein is at the Dept of Zoology, Oregon State University, Corvallis, OR 97331-2914, USA; David Wake is at the Museum of Vertebrate Zoology, University of California, Berkeley, CA 94720, USA.

David Bradford of the University of California at Los Angeles illustrated the decline of the mountain yellow-legged frog (*Rana muscosa*) and Yosemite toad (*Bufo canorus*) from high elevations in the Sierra Nevada Mountains of California. Only about 2% of the lakes that Bradford monitored as having yellow-legged frogs in the mid 1970s were found to have them in 1989. Stephen Corn of the US Fish and Wildlife Service depicted drastic declines of the boreal toad (*Bufo boreas*) in the Rocky Mountains of Colorado and Wyoming.

One of us (ARB) has documented the extreme decline, in the northwestern US, of three species of frogs that were abundant in the early 1970s. In Oregon, of the 30 populations of the Cascades frog (*Rana cascadae*) that have been monitored since the mid 1970s, about 80% of these are now gone. The western spotted frog (*Rana pretiosa*) was abundant throughout the state of Oregon from low to high elevations until the mid 1970s; it is now extinct west of the Cascade Mountains – an extinction from at least one third of its Oregon range. Until the mid 1970s, the red-legged frog (*Rana aurora*) was extremely abundant in the Willamette Valley of Oregon, a large valley (about 160 km by 60 km) sandwiched between the Coastal and Cascade Mountains. Breeding populations of this species are now virtually extinct in the Willamette Valley and, according to Marc Hayes of the University of Miami, populations of this frog have dwindled drastically throughout its range to southern California. Other species of frogs and toads have disappeared from relatively undisturbed ponds and lakes in Colorado, Arizona and New Mexico.

Similar declines of amphibians living in relatively undisturbed areas have been documented from other areas of the world. Michael Tyler of the University of Adelaide has studied the gastric brooding frog (*Rheobatrachus silus*) since its discovery in 1973 in relatively undisturbed areas in the Canondale and Blackall Ranges about 160 km north of Brisbane, Australia. This is a species that could have unlocked many of the mysteries of the physiology of digestion and pregnancy, because of its unique habit of brooding its young in its stomach. The decline of the species began in about 1980, and by 1981 it was thought to be extinct, along with several other sympatric species of frogs.

According to Hayes, the golden toad (*Bufo periglenes*) has dwindled drastically in the pristine Monteverde cloud forest of Costa Rica. In the early 1980s, hundreds of individuals could be captured at several breeding areas. By the mid to late 1980s, the breeding sites generally had fewer than a dozen individuals.

The decline is not seen in all amphibian groups at all localities. For example, the southeastern US shows little evidence of amphibian declines except in areas where there has been obvious habitat destruction. In some regions (e.g. the Rockies of Colorado), species that are in decline co-occur with species that apparently are unaffected. Furthermore, declining and thriving species may be congeneric, suggesting that taxonomic affinity is not correlated with decline. There is little evidence for declines of amphibians inhabiting low-equatorial (within 10° north or south of the equator), low-altitude regions, apart from dramatic losses resulting from deforestation, destructive agricultural practices and rapid urbanization. Robert Inger of the Field Museum of Natural History, Chicago, reported that frog populations on Borneo are not obviously less dense now than in earlier years in areas of pristine habitat.

A world-wide decline of amphibians could have a huge impact on other organisms, including humans. Amphibians are integral components of many ecosystems, often constituting the highest fraction of vertebrate biomass[3]. Moreover, amphibians are top carnivores and are major consumers of invertebrates, especially insects, and of other vertebrates. They are also eaten by predators such as fish, birds, mammals and aquatic insects. Thus, the loss of amphibians in many ecosystems could profoundly affect the populations of the animals that they eat and the animals that eat them.

Moreover, as was brought out clearly by Vaughan Shoemaker of the University of California, Riverside, amphibians are excellent biological indicators of environmental stresses. They inhabit both aquatic and terrestrial habitats – which means that they are exposed to both aquatic and terrestrial pollutants – and they are particularly sensitive because of their highly permeable skin[4], which can rapidly absorb toxic substances. Furthermore, the egg stage is extremely susceptible to chemical pollutants, and exposure to high concentrations of certain chemicals can result in developmental abnormalities[4]. The growth rates of frogs and toads may be significantly affected by even short-term exposure to acid conditions[5], such as may result from acid rain or snow. In fact, John Harte of the University of California at Berkeley presented evidence that is consistent with the hypothesis that populations of tiger salamanders (*Ambystoma tigrinum*) in the Rocky Mountains of Colorado declined due to episodic acidification[6]. In Britain, the range of the natterjack toad (*Bufo calamita*) has shrunk drastically from its original range[7]: natterjack toads are now virtually extinct from the lowland heaths that formerly supported about half of the British populations[7]. This decline has been directly linked to acidification of their habitat[7].

The fact that there is little evidence, at this time, for a single global causal factor for the amphibian declines was emphasized by James MacMahon of Utah State University. However, the participants discussed a variety of possible causes for the declines; these included habitat destruction, introduction of predators such as fish and bullfrogs to areas where they are not naturally found[8,9], pesticide pollution[10], acid rain[6,7] and consumption by humans. (As pointed out by Alain Dubois of the National Museum of Natural History, Paris, the importance of frogs' legs as a food item in France has apparently been linked to a marked decline in native frogs in Europe, India and Bangladesh.) There may be synergistic effects between these more local factors and global factors such as long-term, low-level exposure to increases in ultraviolet radiation and higher temperatures due to global warming.

The workshop panel recommended several immediate courses of action. There are plans to initiate long-term studies of selected populations to identify and monitor both abiotic and biotic factors that could potentially contribute to the declines. Historical records of geographic ranges of species will be compared with current ranges. Experiments are planned that will investigate responses of amphibians to specific pollutants. A future meeting will assess on a global scale the changes in amphibian species richness and diversity, compare the analytical methods used to determine the declines, and formulate methodology for the accurate detection of future declines.

References

1 Andrewartha, H.G. and Birch, L.C. (1954) *The Distribution and Abundance of Animals*, University of Chicago Press
2 Blaustein, A.R. (1981) *Oecologia* 48, 71–78
3 Burton, T.M. and Likens, G.E. (1975) *Copeia* 1975, 541–546
4 Duellman, W.E. and Trueb, L. (1986) *Biology of Amphibians*, McGraw-Hill
5 Pierce, B.A. and Montgomery, J. (1989) *J. Herpetol.* 23, 97–102
6 Harte, J. and Hoffman, E. (1989) *Conserv. Biol.* 3, 149–158
7 Beebee, T.C. *et al. Biol. Conserv.* (in press)
8 Hayes, M.P. and Jennings, M.R. (1986) *J. Herpetol.* 20, 490–509
9 Moyle, P.B. (1973) *Copeia* 1973, 18–22
10 Kirk, J.J. (1988) *Herpetol. Rev.* 19, 51–53