Declining Amphibian Populations

DAVID B. WAKE

WORLDWIDE DECLINES IN AMPHIBIAN POPULATIONS attracted wide attention following a workshop sponsored by the National Research Council (NRC) (*1, 2*). The declines seem to be general, but some regions and many taxa are apparently unaffected (*1*). Are the declines due to "normal" climatic fluctuations, which produce droughts and frosts that can severely reduce population size locally, or are there other, more insidious causes? The report of census data for four amphibians (three salamanders and a frog) gathered during a 12-year period of continuous (daily) monitoring at the Savannah River Site in South Carolina contributes importantly to this question (*3*). Substantial variation was found in breeding population sizes and juvenile recruitment. Population declines were found in some years, but these were coupled with increases; there is a complex dynamic associated with many factors, especially local moisture regimen.

The new data, the most extensive available, raise the possibility that declines are the coincidental effect of population fluctuations. If so, the consequences will vary greatly from place to place. The southeastern United States is a veritable carpet of amphibians, from the abundant salamanders of the highest Appalachian peaks to dense lowland populations of both frogs and salamanders. Should populations decline to local extinction in this area, chances of recovery are high. However, local extinctions have more profound implications in other parts of the world, where species are specialists for habitats that are localized or badly fragmented; under such circumstances, opportunities for recolonization are low to nonexistent (*4*). It is significant that participants at the NRC workshop, who heard a brief summary of the new data, considered it unlikely that global declines were coincidental, because of the number and widespread distribution of the reports, but population fluctuations clearly must be taken into account.

Concern about declines arises because amphibians are abundant, integral components of many diverse ecosystems. They are local top carnivores that are major consumers of invertebrates, especially insects. General declines would have widespread consequences and might indicate more general environmental problems (*5*).

Some declines have been dramatic. Ranid frogs have all but disappeared from southern California (*6*). By the late 1980s a montane frog (*Rana muscosa*) had disappeared from 98% of the ponds in which it had been studied in the mid-1970s in Sequoia–Kings Canyon National Park (*1, 4*). In Oregon, populations of *Rana cascadae*, monitored since the mid-1970s, have suffered about an 80% disappearance (*1, 7*). The golden toad (*Bufo periglenes*), endemic to the Monteverde Cloud Forest Preserve in Costa Rica, has not bred in its traditional breeding sites since 1987; many other frog taxa in the region have experienced declines and local disappearance during this period (*1, 8*). The gastric-brooding frog (*Rheobatrachus silus*), which lived in rivers in relatively undisturbed regions of Queensland, Australia, has not been seen since 1979, and several other sympatric species of frogs also are thought to be extinct (*9*). Sometime after 1981, 8 of 13 species of frogs that had been present in Reserva Atlantica, Brazil, disappeared, including unusual diurnal hylodine frogs, whose birdlike calls were distinctive features of the environment (*10*). Disappearances from protected areas are especially disturbing, because there was reason to think that species in such areas would survive population fluctuations and be immune from most human disturbance.

In general, highland and more northern frogs are more severely affected than other amphibians. Although there is little evidence of problems in tropical lowlands, independent of widespread habitat destruction that is having major impact, data are scant (*1*). Relatively few long-term studies are available anywhere in the world (*11*), so the new data (*3*) have special significance.

In addition to the circumstances described by Pechmann *et al.* (*3*), many other factors have been implicated in declines and disappearances: habitat destruction, conversion of agricultural lands from traditional uses, introduction of predators and competitors, pollution from pesticides, mining and logging, acid precipitation, increased levels of ultraviolet irradiation, consumption by humans, and even general global climate change (*1, 5, 6, 8, 12*). The possibility of synergistic effects between local factors and more global and long-term ones needs attention.

Modern amphibians have been on this planet for well over 100 million years; they are survivors, and their decline is puzzling. Scientific study of amphibians holds promise for a deeper understanding of the resilience as well as the limits of environments (*13*). This is an era of increased concern about issues in biodiversity and its maintenance in the face of environmental changes that many believe arise directly from human activities. Amphibians may serve usefully as bioindicators, organisms that convey information on the state of health of environments. How to read the message, and what to do about it, are timely challenges to scientists and to the public.

Museum of Vertebrate Zoology and Department of Integrative Biology, University of California, Berkeley, CA 94720.

REFERENCES AND NOTES

1. D. B. Wake and H. J. Morowitz, report to Board on Biology, National Research Council, on Workshop on Declining Amphibian Populations, Irvine, CA, 19–20 February 1990; *Alytes* **9**, 33 (1991); A. R. Blaustein and D. B. Wake, *Trends Ecol. Evol.* **5**, 203 (1990); *Bull. Ecol. Soc. Am.* **71**, 127 (1990).
2. M. Barinaga, *Science* **247**, 1033 (1990); K. Phillips, *Bioscience* **40**, 422 (1990).
3. J. H. K. Pechmann, D. E. Scott, R. D. Semlitsch, J. P. Caldwell, L. J. Vitt, J. W. Gibbons, *Science* **253**, 892 (1991).
4. D. R. Bradford, report at the Irvine workshop; personal communication; *J. Herpetol.* **25**, 174 (1991).
5. At the Irvine workshop it was determined that more information was needed; a more specialized workshop was held in New Orleans in August 1991; R. L. Wyman, *Cons. Biol.* **4**, 350 (1990).
6. M. P. Hayes and M. R. Jennings, *J. Herpetol.* **20**, 490 (1986); M. R. Jennings, in *Proc. Conf. Calif. Herpetol.*, H. F. De Lisle, P. R. Brown, S. Kaufman, B. M. McGurty, Eds. (Southwest Herpetologists Society, Los Angeles, CA, 1988), pp. 61–72.
7. A. R. Blaustein, report to the Irvine workshop; personal communication.
8. M. L. Crump, F. R. Hensley, K. L. Clark, *Copeia*, in press.
9. M. J. Tyler, *Alytes* **9**, 43 (1991).
10. P. Weygoldt, *Stud. Neotrop. Fauna Environ.* **243**, 249 (1989).
11. There are a few long-term studies of individual species that have shown marked declines [P. S. Corn and J. C. Fogelman, *J. Herpetol.* **18**, 147 (1984); A. Semb-Johansson, *Fauna (Oslo)* **42**, 174 (1989)].
12. T. C. Beebee *et al.*, *Biol. Cons.* **53**, 1 (1990); J. Freda and W. A. Dunson, *Copeia* **1985**, 415 (1985); J. Harte and E. Hoffman, *Cons. Biol.* **3**, 149 (1989); W. R. Heyer, A. S. Rand, C. A. Gonçalvez de Cruz, O. L. Peixoto, *Biotropica* **20**, 230 (1988); R. L. Wyman, *Copeia* **1988**, 394 (1988); R. L. Wyman and D. S. Hawksley-Lescault, *Ecology* **68**, 1819 (1987).
13. A Task Force on Declining Amphibian Populations (DAP) was formed recently by the Species Survival Commission, International Union for the Conservation of Nature. The DAP will be housed with the newly established Center for Analysis of Environmental Change, a consortium of Oregon State University, EPA/ERL, USFS/CFSL, and Battelle/PNL, located in Corvallis, OR, and will have a full-time coordinator, J. L. Vial. There will be a number of working groups, some regional; one for lower Central America met in Costa Rica in February 1991, and developed a comprehensive plan of action. An Australian Working Group is active and others are being organized. Other groups will be topical; the first of these is developing methods for monitoring populations of amphibians in the context of studies of biodiversity.