Vanishing Amphibians: Why They're Croaking

Scientists this week moved closer to figuring out why certain species of frogs, toads and salamanders have taken a nose dive in recent years and why some have already sung their swan song. At a National Research Council conference in Irvine, Calif., researchers presented strong evidence linking acidic rain and snow—usually viewed as an eastern phenomenon—to salamander deaths in the western United States. Others argued that global climate changes may play a role in the amphibian deaths now plaguing such diverse habitats as the open woodlands of southeastern Australia, the mountain country of northern Colorado and the tropical forests of Costa Rica and Brazil.

Behind the mysterious decline, which apparently began 10 to 20 years ago but only recently received unified attention, lies the possibility that the dying animals are an ominous indicator of human-made environmental problems. "There are some things about [amphibians] that make them a very good 'canary in the coal mine,'" asserts zoologist Henry Wilbur of Duke University in Durham, N.C., referring to the traditional mining practice of detecting toxic gases through their deadly effect on canaries. Amphibian skin readily absorbs chemicals present in soil and water, he says, and the insects these animals eat may harbor other toxic compounds. Moreover, water evaporates quickly from the porous skin, suggesting amphibians may be especially vulnerable to droughts. Wilbur adds that "frogs naturally have great fluctuations in population size" — perhaps reflecting an inherent sensitivity to environmental changes. The key to explaining the scattered distribution of decline among various regions and species, he maintains, is that many amphibians, particularly frogs, need access to several interconnected habitats in order to survive, jumping from pond to pond or from tree to tree when the going gets tough. When alternative dwellings are destroyed, often by human activities, frogs may become sitting ducks for other environmental assaults.

Habitat isolation might help explain the demise of the golden toads that virtually carpeted a small rain forest reserve near Monte Verde, Costa Rica, as recently as 1983, says biologist Marc Hayes of the University of Miami. These creatures, he notes, have an unusual characteristic: They lay eggs only during a 10-day "window" between rainy and dry seasons. Recent fluctuations in that interval could have disrupted the golden toad's life cycle, Hayes suggests. Similarly, rapid melting of acidic snow in the Colorado Rockies can severely damage tiger salamander eggs during a critical five-day period in development, reports John Harte of the University of California, Berkeley.

Hayes and others say stocking lakes with game fish that prey on tadpoles has contributed substantially to the decline of frogs in many U.S. lakes. This, he suggests, might help explain why certain frog species long accustomed to fish-free lakes are the hardest hit in the West.

"The interaction [causing the decline] may differ from region to region, but there is clearly a global problem of some kind—some kind of climate effect," Hayes adds. Researchers point to several interrelated trends: a worldwide warming, increased atmospheric carbon dioxide and methane, and a slight increase in ultraviolet light due to thinning of stratospheric ozone. But they admit that no one really knows how such trends might affect amphibian survival, or whether several small factors added together can devastate an existing population.

For now, says biologist Harold J. Morowitz of George Mason University in Fairfax, Va., the decline may serve as an environmental rallying point for both scientists and the public. "Who cares if 1,000 arachnids become extinct in an Amazon rain forest? That's dynamite to a scientist," he says, "but the public can relate better to Kermit." — *R. Cowen*

Painting a color portrait of stable orbits

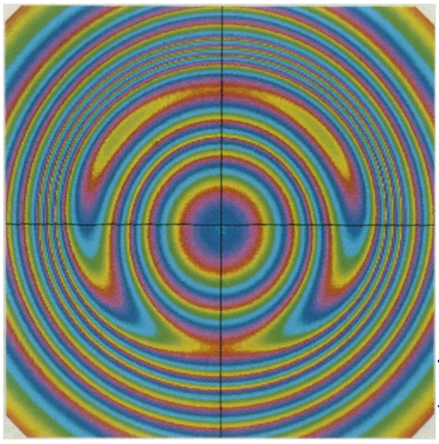
Putting a satellite into a stable orbit is no simple matter. The Earth's bulging equator and other distortions in its gravitational field continually tug at the craft, often causing it to drift away from its planned orbit. Such deviations make satellite tracking difficult. They can also gradually shift a satellite into a position where it can no longer fulfill its mission.

To help aerospace engineers select orbits that stay put, a team of researchers has now developed a technique for visualizing the solutions of equations describing the motions of Earth-orbiting satellites. Using such mathematical "portraits" of orbits, engineers can readily identify equilibrium points and work out the precise conditions needed to lift a given craft into a stable orbit.

"People have had a rough idea of where these orbits are, but they've never had the kinds of tools that we've developed for finding them," says Shannon Coffey of the Naval Research Laboratory (NRL) in Washington, D.C.

An orbiting satellite traces out an ellipse, with the Earth at one focus of that ellipse. For many purposes, the most useful orbits are those in which the ellipse always points in a fixed direction as it sweeps over the Earth. In other words, the orbit's apogee — its most distant point from the Earth's center — would stay over, say, the Northern Hemisphere. In contrast, satellites in orbits for which the ellipse wobbles or tumbles would tend to drift excessively.

Initially, as reported in the Feb. 16 SCIENCE, Coffey and his colleagues applied their visualization technique to a simplified set of equations that included deviations caused only by the Earth's equatorial bulge. Now they can add in much smaller perturbations to get results useful to engineers planning satellite orbits that lie between 300 and 2,000 miles above the Earth's surface, says André Deprit of the National Institute of Standards and Technology in Gaithersburg, Md., who developed the technique with Coffey and NRL colleagues Etienne Deprit and Liam Healy.



Coffey et al./NRL

Equilibrium points corresponding to stable orbits for a given inclination lie at the center of concentric rings. This particular mathematical portrait has two unstable points corresponding to especially undesirable orbits, and three stable points. If the Earth were perfectly spherical, the portrait would be all one color and every orbit would be stable.

"The next step would be to take into account the perturbations caused by the moon and the sun," André Deprit says.

"We have now come full circle," the researchers write in their report. "Analytical study of a dynamical system prompted graphical representations to support our results. Improvements in the visualization techniques revealed new phenomena, which brought us to refine our mathematical analysis." — *I. Peterson*