Extinction: Are Ecologists Crying Wolf?

Some contrarian critics argue that doom-laden prophecies of mass extinctions are based on assumptions that have modest scientific support and are wide open to question

IN 1979, NORMAN MYERS, A NATURALIST IN Oxford and Nairobi, published *The Sinking Ark*, the first prominent example of a now familiar genre—a book warning that the world could "lose one-quarter of all species by the year 2000." Although the danger extended from the whales in the frigid North Pacific to the elephants of the hot African savannah, Myers, like most of those who followed him, focused on tropical forests, the earth's most prolific and diverse biological communities. Claiming that these ecosystems—the home of perhaps one-half of the world's species—were being clear-cut at frightening speed, Myers warned that the ensuing loss of habitat would trigger "an extinction spasm accounting for 1 million species."

In public relations terms, such alarms were amazingly successful: Within a decade public concern had risen to the point that Madonna headlined a rock benefit called "Don't Bungle the Jungle." And estimates of the peril continued to rise. In this issue of *Science* (p. 758), biologists Paul Ehrlich of Stanford and E.O. Wilson of Harvard warn that biodiversity is in such danger that the United States must "cease 'developing' any more relatively undisturbed land" as but a "first step" to a solution. And that doesn't even touch the measures necessary in Third World nations, whose leaders must set aside vast reserves of land at considerable risk to the aspirations of their impoverished people.

That sounds like an awfully severe prescription. But don't make the mistake of thinking Wilson and Ehrlich represent an extreme or fringe point of view. Indeed, according to some critics, Wilson and Ehrlich are representatives of an exaggerated and distorted "bio-dogma" that runs the risk of impeding solutions to tropical forest deforestation—which all sides agree is a severe problem. Among those critics of orthodoxy is Ariel Lugo of the U.S. Forest Service's Institute of Tropical Forestry in Puerto Rico, who has been documenting the effects of deforestation there for a decade. Lugo thinks it's unfortunate that this bio-dogmatism has become entrenched because, he says, "no credible effort" has yet been made to pin down the scientific assumptions behind the mega-extinction scenario. "The fundamental problem that scientists are not able to answer yet is the relation between area lost and species made extinct," he argues. "But if you point this out, people say you are collaborating with the devil."

Lugo is one of a small group of scientists who disagree with the standard view of tropical forest extinction, and hence with the mega-extinction scenario as a whole. Although none is sanguine about humanity's disturbance of the Amazon, all believe that over- or misstating the problem endangers both the credibility of science and the effort to preserve biodiversity. "Wilson may be right, and that's very terrible," says Michael Mares, a zoologist at the University of Oklahoma. "But we should *know* he's right before making these wild demands, and we simply don't right now."

The most prominent of the naysayers is economist Julian Simon of the University of Maryland—a libertarian and nonstop controversialist who has long enraged advocates of population control by arguing that the world can support an almost infinite number of people, because substitutions and technological innovations make resources more plentiful. (In a typical puckish stunt, Simon bet Ehrlich 10 years ago that the world was not running out of resources—and the proof was that any commodity Ehrlich named would actually be cheaper in a decade. Ehrlich picked five metals; Simon won.)

In regard to biodiversity, Simon has argued since 1986 that the widely touted estimates of future extinction rates have no empirical basis whatsoever. Indeed, in two recent lists of extinction assessments—one compiled by Lugo, the other by Richard Tobin, a political scientist at SUNY-Buffalo—only four of 22 predictions came with sufficient explanation to permit independent examination. All of the rest provide anecdotal support—or none at all.

Even one prominent conservationist—who demanded anonymity, explaining that "they'll kill me for saying this"—admitted that "the lack of data does worry me." He then added: "I'm absolutely sure we're right, but a gut feeling isn't much backup when you're asking people all over the world to change their lives completely."

Moreover, the minority critics insist the "doom-and-gloom" scenarios contradict each other. Commentators such as Myers envision the disappearance of a quarter of the earth's species by the end of the century, whereas Ehrlich and Wilson conservatively figure the loss at between 2% and 3% in the same period—an order-of-magnitude discrepancy of the sort that one U.S. Office of Technology Assessment report concedes has "called into question the credibility of all such estimates."

In reply to these criticisms, Wilson agrees that "of course" more data are needed. But, he says, the imminence of the extinction problem, particularly in tropical forests, is "absolutely undeniable." There are "literally hundreds of anecdotal reports." He adds

CRITICS TAKE ON THE "BIO-DOGMA"

	Assumption	Criticisms
Habitat loss	Most predictions of species loss are based on using islands as a model.	Mainland territories behave differently from islands—if original habitat is lost, species may escape into bordering areas. Data on habitat loss are frequently misleading.
Species-area curve	Current models of the relation between species and geographic area imply that an infinite increase in area implies an infinite increase in the number of species.	Critics argue that, in fact, the curve levels off at its upper reaches. Therefore, habitats on the upper part of the species-area curve can be reduced without substantial species loss.
The number of species	During the 1960s, researchers realized the incredible biological diversity of tropical forests and estimates of the number of species shot up—leading Wilson and Ehrlich to posit that 100 million species may live on Earth.	In fact, taxonomists have managed to name only 1.4 million species, and the actual total is a matter of speculation. Catastrophical estimates of extinction are based in large part on species no one has ever seen.

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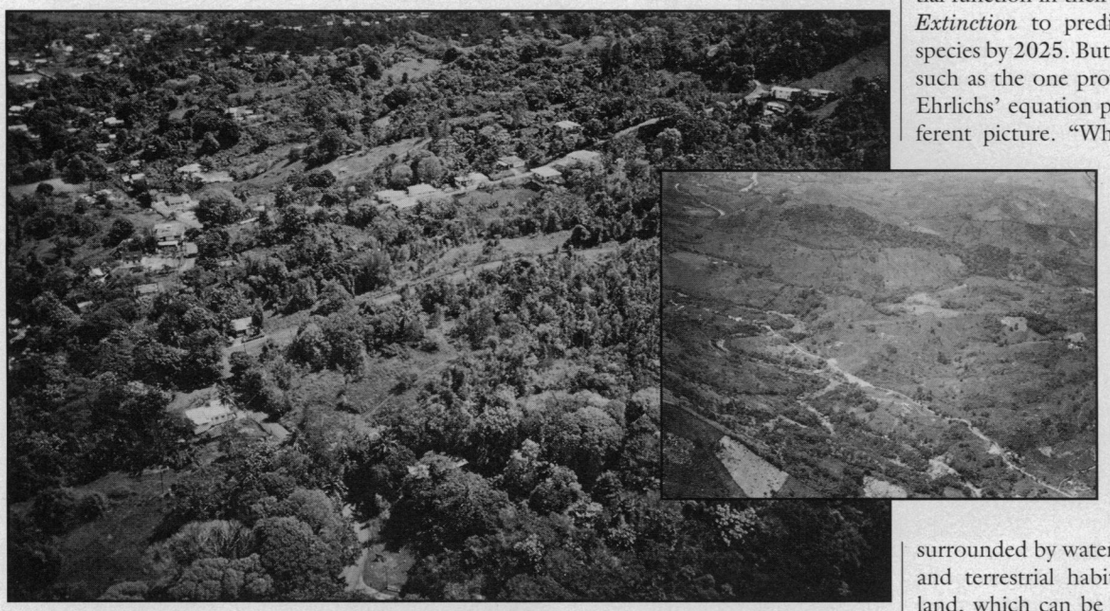
Part of the reason we don't have a clearer idea of extinction rates lies in the difficulty of estimating them. Serious efforts to calculate those rates hinge on the "species-area curve," which is based on the simple observation that every community of species needs a habitat. The larger the habitat, the more species it can support. In the 1960s, Wilson and the late Robert H. MacArthur tallied the number of species on islands of various sizes, eventually constructing what is now known as the theory of island biogeography. The theory is usually summed up by the rule that N, the number of species, is proportional to $A^{.27}$ where A is the area. Extinction curves are calculated by inverting the relationship: treating habitats as "islands" and asking what happens to species as the island shrinks. Clearly, if a habitat drops below a minimum size, the community as a whole will cease to exist. But how fast does this take place? How much room is there for recovery? "The rule that is followed for teaching purposes," Wilson says, "is that for every 90% loss in area, the number of species that can live indefinitely there is cut by one-half."

In other words, the consequences of cutting down 90% of a tropical forest will be a forest of one-tenth the size with half as many species living in it—a scenario, Wilson stresses, that minimizes the damage. "Imagine in your mind an area of rain forest in southern Surinam. Now imagine cutting into the edge of it and reducing it 90%. You get that fall toward one-half in a system in which species are widespread. But if species are highly localized in their distribution, the loss will be far higher. If all species are in small, local, endemic communities, then the percentage loss of species will approach the percentage loss of area."

This is the point at which the skeptics open their assault on accepted wisdom. "The theory of island biogeography was originally developed to model what happens to the size of animal populations on islands," Lugo says, but "deforestation and extinction are entirely different." To get extinction rates from the island theory, he notes, requires three key assumptions: the rate of habitat loss, the shape of the species-area curve, and the absolute number of species. And all three are wide open to question, the critics say.

■ *Habitat loss*. Deforestation statistics, especially for the Amazon delta, are frequently misleading. According to Thomas Lacker, director of the Archbold Tropical Research Center at Clemson University, Brazilian government deforestation figures are for a political unit called "Amazonia," which rain forest advocates take as equivalent to rates of deforestation. But Amazonia consists of several types of forest and a large expanse—more than a third of the region—of savannah (*cerrado*) and semidesert (*chaco*). "The cerrado and chaco are being destroyed at a much faster rate than anything else," Lacker says. "The rate at which they're being gobbled up by soybean plantations is staggering. Then comes the dry forest, and last is the moist forest. So the actual wettest forest, which is what most of the attention is focused on, is not being hit as much as people sometimes think."

Figures from Cleber Alho, director of the Brazilian branch of the World Wildlife Fund, back him up. In figures sent to *Science* from his office in Brazil, Alho calculates the rate of actual forest clearing at 0.5% a year—a figure he concedes is "horrible," but which is half the size of what's usually cited. Ehrlich and his wife, biologist Anne Ehrlich, made use of the higher annual rate of 1% and an exponential function in their well-known 1981 book *Extinction* to predict a near-total loss of species by 2025. But plugging a lower figure, such as the one provided by Alho, into the Ehrlichs' equation provides a startlingly different picture. "What's going on is bad," Mares says. "But we have more time and room than the doomsayers let on."



Comeback. *An area of Puerto Rico, deforested in the early 1900s, supports a rich growth of trees today.*

Second, as the critics point out, deforestation is only roughly equivalent to actual habitat loss. Island biogeographical calculations assume that nibbling into a forest is like cutting off a piece of an island. But islands are surrounded by water, a hostile environment, and terrestrial habitats are surrounded by land, which can be entirely different. In an address before the National Forum on Biodiversity in 1986, Lugo pointed out that according to the only available study of the rate of increase in tropical secondary forests, almost half of the 11.3 million hectares of virgin tropical forest cut annually were turned not into wasteland—the equivalent of water in biogeographical calculations—but secondary forest. Another million hectares of secondary forest was created through reforestation or natural regeneration. Secondary forests are poorer, less diverse ecosystems than virgin forests, he said; but they are not necessarily disasters. (His audience did not appreciate hearing what might be considered good news—"I almost got eaten alive," Lugo says, with one eminent conservationist "yelling at me in the cafeteria of the Smithsonian.")

■ *The species-area curve*. Patrick Kangas, of the University of Maryland, on the other hand, critiques current views about the species-area curve, which is supposed to explain the relationship between an area available for wild populations and the number of species that area can support. At present, the exponential relation derived from the island studies of Wilson and MacArthur means that an infinite increase in area implies an infinite increase in species number. ("The species number increases smoothly with area up to the largest area you can look at," says Jared Diamond, a physiologist and ecologist at UCLA.) But according to Kangas, the appar-

ent increase in number of species is a trivial consequence of the fact that a large area will contain a large number of ecosystems. As biologists cross borders from one community to another, they register sudden influxes of new species; this, he says, tells you nothing except many ecosystems have many species.

What is more important is the shape of the curve *within* a single community—and that, he says, is a very different matter. "There's a finite number of species within any community type," he says. "As you continue to move out, the number levels off." Further increase in area, in sum, does not produce concomitant increase in diversity. The result, the critics argue, is that habitats on the upper, flatter part of the species-area curve can be reduced without substantial immediate species loss—and hence, some of the habitat destruction we're now seeing in the world may not, in fact, translate into any loss of species.

When Kangas first explained his views at the International Congress of Ecology in 1986, he joined the select club of scientists who have been attacked in scientific articles for papers that have not yet been written. And, he says, he continued to be vilified for some time. "Please don't say I'm in favor of cutting down the rain forests," he asks from Belize, where he is doing fieldwork. "Because I'm absolutely not. But I think we've got ourselves into the position of following some kind of orthodoxy, rather than following the science."

■ *The number of species*. The problems of estimating habitat loss and computing the species-area curve are daunting enough. But there's an even bigger, more fundamental problem for those who are raising the alarm about extinction: science's taxonomic ignorance. Dennis Murphy, director of the Center for Conservation Biology at Stanford, says flatly, "Nobody knows how many species there are." As a result, those who prophesy the end of half of the world's species find themselves in the awkward position of predicting the imminent demise of huge numbers of species nobody has ever seen.

"Until the 1960s," Murphy says, "we thought there were maybe 3 or 4 million species, of which we had catalogued a million. Then people began to realize the incredible diversity of tropical forests, and guesses started shooting up." On the basis of new sampling techniques, Terry Erwin of the U.S. National Zoo calculated that there are 30 million species of insects; recently, mycologist David Hawksworth reckoned that there are 1.5 million types of fungi. And no scientist has even a guess at how many microorganisms remain to be added to the tally, a situation that led Wilson and Ehrlich to posit that the number of species may be close to 100 million. In the meantime, they note, taxonomists have managed to award scientific names to about 1.4 million species, less than 2% of what they argue is the total. Noting that the world's supply of taxonomists is far too small for the task of tallying the world's species, Wilson and Ehrlich call for a kind of national biodiversity project.

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—E. O. Wilson

And without such a national—perhaps international—effort, knowing how many species are going extinct will be, as Kangas puts it, reminiscent of the question of what sound a tree makes if it falls in the forest but there's no one around to hear it. If species are not discovered in the future, one cannot be sure whether they became extinct or never existed in the first place. As a result, Kangas says dryly, the "whole business is unfalsifiable, and everyone in science knows what a mess unfalsifiable theories are."

Questions such as these can best be answered by resorting to empirical evidence. And here, critics argue, the data for the mega-extinction scenario is at best ambiguous. One source of information is the study of isolated communities, such as solitary mountaintops or desert oases—and those have tended to confirm the laws of island biogeography. "One of the famous examples is a mountain ridge in Ecuador," Wilson says. "In a relatively small ridge of a few square kilometers, they found something like 90 species of plants found nowhere else. Between 1978 and 1986, farmers cleared the ridge, and extinguished most of the species in one shot."

Diamond, for his part, examined an isolated forest reserve in Java. Comparing bird species in the 1980s to those listed by a resident bird watcher in the 1930s, he found that the square-mile reserve had lost more than half. "Bird extinction rates are obviously very different from those of other taxa," he says. "They're highly vulnerable to habitat change. But the implication was clear."

But other measurements of larger, less isolated ecosystems—communities perhaps more representative of large rain forests—have yielded different results. "Look down at the eastern United States the next time you fly over it," Mares says. "It used to be solid forest all the way to the Mississippi. Now it's patches of isolated forest, exactly what we fear will happen to the tropics. But we didn't have a massive die-off." Rain forests are different than temperate forests, he agrees, but the evidence from the United States suggests that simple predictions from species-area curves are "glib."

Most champions of tropical ecosystems say deforestation is well-nigh irreversible because forest soils are nutrient-poor: Food stocks are held mostly in living creatures and are quickly recycled. In clearings created by logging, rain washes away all value from the soil, leading to a barren, brick-hard surface that will remain for centuries. Extinction is thus the likely alternative. But evidence from Puerto Rico suggests this alarming scenario is not the only alternative. In a frightening example of environmental degradation, the island, one of the few tropical places where long-term biological records have been kept, was almost completely stripped of virgin forest at the turn of the century. Yet it did not suffer massive extinctions. Even birds lost only seven of 60 species—a painful, even unacceptable, total, but not an eco-catastrophe. Now, 90 years later, Puerto Rico is thickly covered with trees.

As Lugo concedes, this relative good fortune may have occurred because the native fauna, evolved through many hurricanes, was adapted to living in a disaster zone. But, he argues, the lesson is clear. "We are asking Latin countries to go to enormous efforts on the basis of a scientific theory that is full of uncertainties," he says. For Kangas, the key issue is a practical one. "For policy questions," he says, "the essential point is that not all forest-clearing is the same." And conservationists need to offer decision-makers "low-impact alternatives" rather than issuing blanket predictions of disaster. Adds Mares, "If we keep saying things are going to go extinct tomorrow and they don't, people are going to stop believing us. And that will hurt us the day after tomorrow, when they may actually go extinct." ■ CHARLES C. MANN

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