Rare Habitats Vie for Protection

A new approach to saving biological diversity focuses on beleaguered ecosystems even if they do not house an extraordinary number of plant and animal species

The landscape is far from lush, and it is no longer home to many of the rare species, such as the Mexican wolf, that once roamed this arid, southwestern corner of New Mexico. But a closer analysis reveals at least part of the reason the Nature Conservancy paid $18 million in 1990 for the 140,000-hectare Gray Ranch: It hosts fully 45 different ecosystem types, from semidesert grasslands, oak woodlands, and chaparral to Douglas fir forests. There's even a rare "playa" lake, a marshy, short-grass remnant of the last ice age that sits like an orphan, hundreds of miles from others of its kind. "We're moving away from conservation of species to conservation of ecosystems," says Patrick Bourgeron, a senior ecologist with the Nature Conservancy.

In New Mexico and around the world, conservationists are revising their strategies for protecting biodiversity as biologists trained in landscape ecology clash with those immersed in more specialized studies of species. Land and funding are always limited, and species and the threats they face are never distributed evenly across the planet. So where should the safe havens be placed? In recent years, conservation biologists have focused on protecting areas which house an extraordinary number of species, such as the Brazilian Amazon. But now a growing chorus of conservationists is saying this approach is deeply flawed. Among other problems, it can overprotect tropical rain forest creatures at the expense of whole families of species in temperate and arctic regions. Says Eric Dinerstein, chief scientist at the World Wildlife Fund (WWF): "In the past, policymakers believed biodiversity equaled tropical rain forest equaled Brazil. We need to change that equation because it doesn't take into account the extraordinary biodiversity found in other habitats."

And indeed, the WWF, the Nature Conservancy, and to a degree the World Bank have begun setting their sights on saving endangered ecosystems rather than saving the maximal number of threatened species. Their goals now include establishing a portfolio of reserves that represent the full spectrum of habitat types. With this new approach, New Mexico's Chihuahuan desert, the Argentine pampas, and Trinidad's coastal mangroves become top-priority conservation targets even though none house stunning numbers of species. "[We] don't want to ignore places that are low in biological richness if the species there are found nowhere else," says Deborah Jensen, director of the Nature Conservancy's conservation science division.

When the biodiversity crisis was first sounded in the mid-1980s, biologists scrambled to come up with a triage system for identifying the best places to protect as parks and nature reserves. In the late 1980s, Norman Myers, an environmental consultant in Cambridge, England, came up with a map of 10 global biodiversity "hot spots"—later revised to include 20 regions—where large numbers of species faced immediate threat. His map was based on three considerations: a habitat's total number of vascular plant species—thought to be a good proxy for overall biological richness; the number of those plants that were endemic (found nowhere else); and how much of the habitat was threatened by machetes, power saws, and backhoes. Not surprisingly, given the density of plant species in tropical forests, most of Myers's hot spots were sprinkled across the tropics. Indeed, in his first map, there were no hot spots in any temperate or arctic regions, although a few temperate spots were added later in California, Africa's Cape province, and the Eastern Himalayas, among other places.

WWF

TONY RATH/WWF

Not tropical. The Mexican desert *(top)* and U.S. longleaf pine savanna *(above)* house rare assemblages of species.

Funding organizations such as the World Bank and the MacArthur Foundation jumped on Myers's creation. It was based on "back-of-the-envelope calculations, [but] it was the best we had," says George Ledec, an ecologist at the World Bank's Latin America and Caribbean Unit. Thus far, at least $200 million has been invested for conservation programs in areas designated as hot spots—$100 million from the World Bank's coffers alone, according to Myers. Many protected areas in the Amazon, particularly in the tropical Andes and the Atlantic coast of Brazil, came about largely in response to "hot spots" publicity.

But dissatisfaction with the hot spots approach has grown in recent years. Although most conservation biologists concede that it has helped focus attention on the biodiversity crisis, many argue that it has not stood up to scientific scrutiny. According to the Nature Conservancy's Jensen, one fundamental assumption has turned out to be plain wrong—that places high in biodiversity for plants or birds are also high in biodiversity for other groups, such as butterflies or amphibians. "Is there overlap? At all levels of analysis, the answer has turned out to be no," she says.

Other conservation biologists point out that the hot spots approach not only neglects species living in deserts, grasslands, and temperate forests but it ignores the fact that higher taxonomic orders of species may have greater conservation value. Put another way, the hot spots approach would save hundreds of species of closely related tropical orchids but overlook New Zealand's tuatara, a large, iguana-like reptile that is the sole survivor of a group that flourished more than 200 million years ago during the Triassic.

In response to these criticisms, Myers and Russell Mittermeier, president of Conservation International, are preparing a new version of the hot spots map for release early next year. Their new schema will now give some weight to organisms other than plants. In it, a hot spot must be undergoing a rapid loss of vegetative cover and be home to at least 1250 endemic flowering plants (one-half percent of 250,000 known species); it also has to contain a number of endemic

Some Biologists See Holes in Gap Analysis

It's one thing to say that all types of ecosystems should be represented in a network of refuges, as many conservationists have done (see main text). It's quite another to get information about the geographic distribution of species that measures up to scientific standards. "It can be a garbage-in, garbage-out problem," says Daniel Simberloff of Florida State University in Tallahassee.

To target the best places for protection, conservation biologists often overlay maps of different species' ranges in a technique called "gap analysis." Michael Scott, now with the Biological Resources Division of the U.S. Geological Service (USGS) in Moscow, Idaho, performed the first such analysis in 1978 when he placed range maps of Hawaii's endangered birds—derived from his own field surveys—over a map of existing reserves, and found very little overlap, a "gap." One unprotected site was especially rich in endangered birds; eventually it was set aside as the Hakalau Forest National Wildlife Refuge. "It would not have been possible to see it without a graphic presentation," says Scott.

Today, Scott's technique is used by conservation biologists worldwide. The World Conservation Monitoring Centre in Cambridge, U.K., has used gap analysis to identify underprotected ecosystems across the tropics. In the United States, the National Biological Service (now the USGS Biological Resources Division) officially embraced the technique. In Florida, gap analysis has helped determine which sites should be acquired for the Conservation and Recreation Lands program (*Science*, 21 July 1995, p. 318). Further, state and local agencies are beginning to use the technique when developing land-use plans.

But a gap analysis is only as good as the maps that go into it, and they can be pretty unreliable. Says Jay Hestbeck of the University of Massachusetts in Amherst, "We need to retain some skepticism about our ability to map species, otherwise we're just fooling ourselves." At the USGS, for instance, biologists start by piecing together vegetation maps from satellite images and from information on expected vegetation. They then feed the maps into a computer model, which extrapolates from the plant data to generate range maps of animal species. But critics point out that the resolution of the satellite images is too low to identify small, biologically important habitat patches. And Tom Edwards, a USGS ecologist at Utah State University in Logan, and others question the validity of extrapolating from plants to animals.

Edwards conducted field surveys to check the accuracy of Utah's gap analysis maps and found they were only 75% accurate for vegetation, 80% accurate for reptiles, and 70% accurate for amphibians. Improving the models would require a lot more information on the life histories of species, he says. Scott readily concedes that the gap maps have their flaws, but says they are designed primarily for coarse-level planning.

Indeed, most agree that the maps of vegetative cover the USGS is creating for the United States will be valuable for monitoring landscape-scale changes over time, if not for identifying concentrations of species. And according to Reed Noss, editor of *Conservation Biology*, the new computer-generated vertebrate range maps, while not perfect, are "orders of magnitude better than the range maps you see in field guides." **–K.S.**

species at higher levels of organization. For instance, Madagascar qualifies as a hot spot because of its plant diversity, its high number of endemic birds (five families) and lemurs (five families), and because it has a variety of unusual reptiles, including nearly half the world's chameleons.

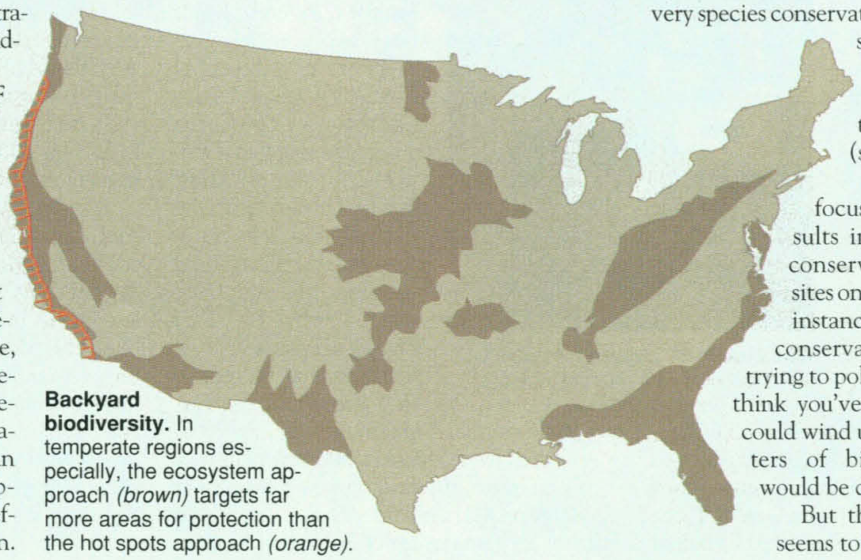
According to Mittermeier, the new map comprises about 25 hot spots that, taken together, represent more than 30% of all the narrow-range endemics and at least two-thirds of the most endangered terrestrial species. "If you're talking about investing strategically, there's no way of avoiding these areas," he says.

But last month the WWF unveiled an entirely different, ecosystem-based triage strategy. "The Global 200: Key Ecoregions for Saving Life on Earth" highlights 217 terrestrial, marine, and freshwater priority "ecoregions" that get high scores when rated for rareness of habitat type worldwide, endemism, total number of species, and unusual ecological phenomena such as the mass migration of caribou in the Canadian tundra. "The [ecosystem] approach is a more rigorous and effective way to do conservation. ... It buys you almost everything. If you capture all ecosystems in all ecoregions and maintain them, you could save the majority of species," argues the WWF's David Olson. The WWF map identifies the hot spot areas as important targets for biodiversity conservation but adds many additional high-priority regions. For example, the last hot spots map includes three areas on continental Africa—in Ivory Coast, South Africa's Cape, and Tanzania—while the new WWF map adds about three dozen more areas throughout sub-Saharan Africa.

This ambitious effort has its critics. The boundaries for ecoregions are not as clear as they're often made out to be, says Bob Jenkins, president of BioDiversity Institute, a nonprofit conservation organization in Key West, Florida. For instance, vegetation maps often are based on satellite imagery supplemented with information on expected plant life given an area's latitude, elevation, and position in the landscape. But on the ground, the habitat may be so disturbed that it no longer hosts the very species conservationists are trying to preserve. "I assume there's an awesome amount of error [in most ecosystem maps]," says Jenkins (see box).

Mittermeier adds that focusing on ecosystems results in long lists of priority conservation areas—the 217 sites on the Global 200 map, for instance—which could diffuse conservation efforts. "If you're trying to politically sell 200 places, I think you've lost it," he says. "You could wind up losing the major centers of biodiversity—and that would be disastrous."

But the ecosystem approach seems to be winning converts. A



SOURCE: WWF/NORMAN MYERS

Backyard biodiversity. In temperate regions especially, the ecosystem approach *(brown)* targets far more areas for protection than the hot spots approach *(orange)*.

map of the terrestrial ecoregions of Latin America and the Caribbean released by the WWF and the World Bank last year—a forerunner to the Global 200 map—has helped shape planning for the region by the Nature Conservancy and the World Bank. Argentina is in the midst of developing a national, ecoregion-based conservation plan. And upon release of the Global 200 map, the President of the Republic of Sahka, formerly Yukatia, in eastern Russia, protected 70 million hectares of taiga, according to the WWF.

One place already testing the ecosystem approach for selecting protected areas is the Caribbean nation of Trinidad and Tobago. Although it was never considered a biodiversity hot spot, it has an abundance of ecosystem types, including montane rain forests, savannahs, wetlands, and coral reefs. "Trinidad and Tobago had no properly protected areas—it was a blank slate, a real opportunity to start from scratch and propose a network of natural areas using good science," says Stan Temple, a conservation biologist at the University of Wisconsin in Madison who worked there in 1995–96.

To select and design potential reserve sites, last January Temple and the local Caribbean Forest Conservation Association launched a priority-setting exercise. Using remote-sensing imagery, they first determined that only 20% of the islands remained in a fairly natural state. Then they used maps of elevation and vegetation to identify the islands' ecosystem types. Since it appeared that, generally, birds were a good indicator of biodiversity on the islands, they developed a computer model based on vegetation and elevation maps to predict where the islands' 420 bird species would be concentrated. Later, consultations with ecotourism guides validated the model's predictions of bird distributions. Then they pinpointed the rarest ecosystems, using ferns as indicator species for minimally disturbed areas. By August, the team had a proposal for eight protected areas ranging in size from 643,000 hectares of tropical montane forest to 700 hectares of mangroves and a coral reef.

That month, the World Bank agreed to help Trinidad and Tobago implement the plan. But whether the islands' ecosystems are added to the world's reserve network will depend on passage of new national legislation and development of conservation policies. Says Temple, "The islands now need to start thinking in terms of the long-term strategies for moving [the areas] steadily toward protection and management."

As Jenkins points out, conservation value isn't the only thing that determines which sites actually get protected. Whether planners use the ecosystem or hot spots approach, he says, when it comes down to selecting actual sites "the biggest problems often are the practicalities—availability of lands, money, and capturing the attention of decision-makers." For these islands and for the ecosystem approach to saving biodiversity, the future looks promising, but the next steps will be crucial.

–Karen Schmidt

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LIFE ON MARS

Martian Rocks Tell Divergent Stories

The life on Mars story took on new life of its own last week, as the international scientific community tried to fathom the meaning behind two dueling studies of meteorites from Mars. One study by a British team follows up on the original claim—that minerals deposited 3 billion years ago in a bit of Martian crust that later fell to Earth carry the hallmarks of past life (*Science*, 16 August, pp. 864 and 924). Making a bold splash in the press, the team cited strong new evidence of ancient life in both the original Martian meteorite and a second one. But another study, presented with less fanfare at an American geological meeting, suggests that both meteorites may bear the remains of Earthly contamination instead.


DAVID J. PHILLIP/AP

Good sample? Meteorite ALH84001 won't get dirty now, but did it before?

To most researchers, this round leaves the story little closer to a resolution. But the public was clearly wowed by the British work by meteoriticists Colin Pillinger, Ian Wright, and Monica Grady of The Open University in Milton Keynes, who presented their as-yet unpublished data at a meeting at the Royal Society in London and later gave a press conference. They analyzed the isotopic composition of three samples from carbonate globules in the original Martian meteorite, ALH84001, focusing on the proportion of carbon isotopes. The ratio of carbon-13 to carbon-12 can suggest life, since metabolic processes deplete organic matter of heavy carbon. In earlier work, the team had detected moderate isotopic depletion in a different Martian meteorite. This time, they found dramatic depletion in one of their three samples, to values about twice as light as most terrestrial organic matter. On Earth, the only credible source of such light carbon would be the methane produced by certain microbes, implying that this sample indeed holds traces of ancient life.

Everett Gibson of NASA's Johnson Space Center, who co-led the group that first found evidence for life on Mars, says he's pleased with the new support. He notes that if these findings hold up, then life may have existed on the Red Planet over much of its history: the meteorite that the Open University team analyzed previously, EETA79001, was ejected from Mars just 600,000 years ago.

Then again, the finding may say nothing about life on Mars, if Jeffrey Bada is right about Earthly contamination of Antarctic meteorites. The Scripps Institution of Oceanography geochemist spoke last week at an early Sunday session at the Geological Society of America in Denver. Last year, Bada analyzed the amino acids in bits of EETA79001; some meteorites carry these compounds, presumably made by nonbiological processes. But the composition and L configuration of this meteorite's amino acids matched those on Earth. And Antarctic ice carries a surprising amount of such amino acids, Bada says.

Now, in the same meteorite, Bada has found an Earthly signature in another set of compounds—the polycyclic aromatic hydrocarbons (PAHs) that Gibson's team found in ALH84001 and interpreted as the degradation products of life. Bada saw a similar spectrum of PAH size and structure in EETA79001 and in Antarctic ice—a spectrum much like that of ALH84001. Since both Martian meteorites spent thousands of years in Antarctic ice, Bada sees contamination problems for both. "This looks like stuff from Earth," he says. "It's extremely dangerous to make these bold claims."

Wright counters that "there are no terrestrial contaminants" on Antarctic ice that could account for the extreme isotope values in ALH84001. And contaminating only a few specks inside a single rock is highly unlikely, he adds. What's needed to sort all this out, researchers say, is more analysis and more communication. The two groups have two very different kinds of data, notes geochemist John Hayes of the Woods Hole Oceanographic Institution. "Until they get together, it's really tough to say much."

–Richard A. Kerr