The High Cost of Biodiversity

A controversial plan to protect North American biodiversity calls for nothing less than resettling the entire continent. That may be too much to ask of the people who already live there

To all appearances the gathering at Arizona State University in Tempe, Arizona, was an ordinary scientific conference—a mix of Oxford cloth and Birkenstocks, with a preponderance of male facial hair. But ordinary is the last word to describe what was presented at the seventh annual meeting of the Society for Conservation Biology on 11 June: the Wildlands Project, the most ambitious proposal for land management since the Louisiana Purchase of 1803. Designed to protect biodiversity in North America, the project calls for a network of wilderness reserves, human buffer zones, and wildlife corridors stretching across huge tracts of land—hundreds of millions of acres, as much as half of the continent.

The sweep of the idea elicited gasps from the audience. On the Oregon coast, for instance—a shoreline dotted by small towns and inundated by millions of summer tourists—the Wildlands approach calls for 23.4% of the land to be returned to wilderness, and another 26.2% to be severely restricted in terms of human use. Most roads would be closed; some would be ripped out of the landscape. The plan does not specify what would happen to the nearby inhabitants. Similar alterations are called for in Vermont, Florida, the mid-Atlantic region, and the rest of the country.

In fact, the long-term goal of the Wildlands Project is nothing less than a transformation of America from a place where 4.7% of the land is wilderness to an archipelago of human-inhabited islands surrounded by natural areas. It is, said ecologist Reed F. Noss, one of the plan's architects and the editor of the journal *Conservation Biology*, "a vision of what this continent might look like in 200 years if we can reduce the scale of human activities."

The whole notion may seem wildly impractical—the musings, perhaps, of a handful of radical activists. Yet the principles behind the Wildlands Project have garnered endorsements from such scientific luminaries as Edward O. Wilson of Harvard, Paul Ehrlich of Stanford (who describes himself as an "enthusiastic supporter"), and Michael Soulé of the University of California, Santa Cruz, who is one of the project's founders. In their view this approach is the logical culmination of ideas about reserve design that have already influenced land-use plans from the Pacific Northwest, where these ideas are being used in the design of a web of spotted owl reserves, to Florida, where parts of an early regional Wildlands Project have found their way into the state's land acquisition proposals. "In some ways the Wildlands Project seems nuts," says one prominent ecologist, who asked for anonymity because he hadn't had time to consider the proposal carefully. "But then you think about it, and it is more or less where the science is pointing to."

The science is pointing in this direction largely because of a growing conviction among conservation biologists and other scientists that native species, especially big carnivores such as wolves, grizzly bears, and mountain lions, need enormous amounts of space to survive. Giving animals that space can be viewed as the logical extension of laws such as the Endangered Species Act, which mandates that biodiversity must be saved no matter what the cost. But critics of the project say that if the science points to costs that are so enormous, plants and animals will become part of an "us-versus-them" battle in which they don't stand much of a chance.

"I can tell you, from having watched this issue for some time, the people who would be impacted by such reserves are absolutely terrified by them," says Dave Redmond, press secretary to Representative Bob Smith, an Oregon Republican who has introduced legislation to scale back the Endangered Species Act. "Shutting down broad swathes of the United States—politically, that is just undoable." If something like the Wildlands Project is what it will take to preserve biodiversity, Redmond says, then some biodiversity will have to go. "That," he says, "is what we're facing."

Linking the fragments

The project began in 1980 as a gleam in the eyes of Dave Foreman, a founder of Earth First!, the radical environmental group that became notorious for physically attacking projects its members deemed environmentally undesirable. "My feelings have

Off limits. Core refuges, buffer zones, and wildlife corridors will dominate the Oregon coast in a Wildlands proposal.

evolved," Foreman says, noting that he no longer participates in such guerrilla actions, "but my primary goal has always been the same—big wilderness areas with large predators in them." In November of 1991, Foreman met in San Francisco with a dozen other activists, including Noss. Out of that meeting grew the Wildlands Project, an attempt to coordinate and encourage regional conservation plans.

"We wanted to make conservation proactive, rather than reactive," says project director David Johns, a political scientist at Portland State University. "We're always in the business of saying no to people—no you can't develop, no you can't log—which makes it seem as if we have no positive vision. Well, *this* is that positive vision. Now we can say, here on the basis of sound, peer-reviewed science is what we think is necessary to keep ecological processes going or prevent a mass extinction event." (In fact, the Wildlands plan has not yet been peer reviewed.)

Conservation biologists describe much of the human impact on biodiversity in terms of habitat fragmentation—the subdivision of large, contiguous habitats into smaller tracts. Fragmentation isolates the tracts from one another, increases the ratio of edge to interior for each tract, and reduces the total area of habitat. The effect is to transform the pieces into islands that individually carry fewer members of each native species and experience more invasions by exotic species.

In the past, the chief counterforce to the loss of habitat has been the creation of nature reserves: parks, wildlife refuges, wilderness areas, and so on. But most parks and wilderness areas were set aside because they were pretty, and because they had little of value to mining, timber, and cattle interests; biological factors, Soulé points out, were generally not considered. Even wildlife refuges were created with the goal of protecting a particular type of species, such as the ducks beloved by hunters, rather than an ecosystem or biodiversity as a whole. As a result, such areas tend to be beautiful, but not particularly species-rich. Worse, environments designed to be favorable to one species may actually become unfavorable to others, increasing rates of local extinction overall.

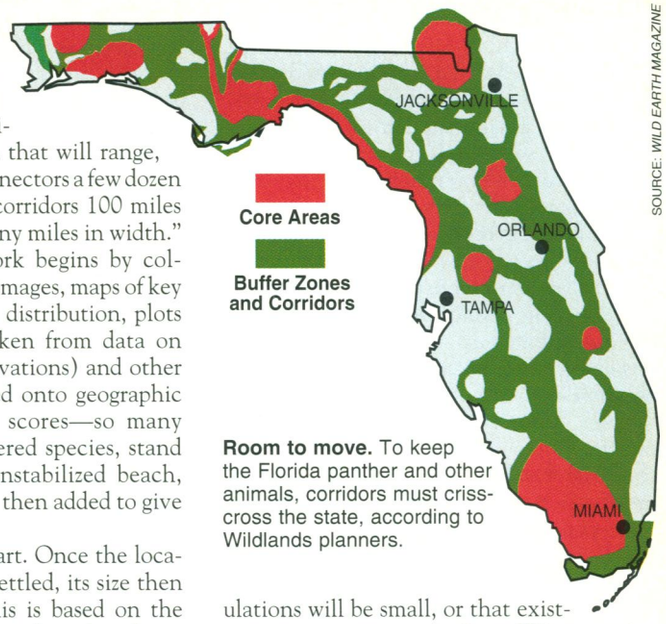
The Wildlands Project aims to rectify that. The proposal's heart is the "regional wilderness recovery network"—a model, developed by Noss, for reversing habitat fragmentation in North America. It consists of three elements: core reserves, buffer or multiple-use zones, and connecting corridors. Core reserves, consisting of a quarter or more of the area in any given bio-region, would be off-limits to much human activity. They would cover a representative sample of all native ecosystems, and be large enough to maintain viable populations of all native species. Girdling them would be buffers, insulating reserves and providing supplemental habitat. To prevent isolation, each reserve would be linked to its neighbors by corridors of native vegetation that will range, Noss says, "from short connectors a few dozen meters wide to regional corridors 100 miles or more in length and many miles in width."

Designing this network begins by collating data from satellite images, maps of key plant and animal species distribution, plots of wildlife routes (as taken from data on road kill and other observations) and other sources. These are plotted onto geographic areas that are awarded scores—so many points for every endangered species, stand of old-growth timber, unstabilized beach, and so on. The scores are then added to give areas ecological priority.

But this is only the start. Once the location of a core reserve is settled, its size then must be determined. This is based on the home ranges of large mammals within them, and how many of those animals are needed to maintain a viable population. Through radio telemetry, biologists have estimated the home range of many of these species. The home ranges are enormous. For example, the Fish and Wildlife Service's draft recovery plan for the grizzly suggests that each animal requires 76 square kilometers of roadless land. Typically, Soulé says, such mammals need populations of several thousand to survive inbreeding, disease, and demographic stochasticity (the chance that, say, the offspring of a small group are mostly one sex). Considering these numbers, Gary Belovsky of the University of Michigan argues, leads to the inescapable conclusion that maintaining viable populations of animals with big home ranges will require setting aside regions of up to a million square kilometers—areas, that is, about the size of California, Nevada, and Oregon combined, and many times the size of even the largest national parks.

These numbers do come with some questions. Mark Shaffer, vice president for resource planning at the Wilderness Society, pioneered this approach for determining population viability—known as population viability analysis (PVA)—in 1981. "Unfortunately," he says, "a lot of [PVAs] aren't very good at all. The life characteristics of fewer than a dozen species are known well enough to be used in these models." Furthermore, he notes, there's a real lack of empirical testing. "I don't think anyone has looked at PVAs, seen the kind of data they require, and then gathered it—still less directly tested one."

It's true that PVAs have not been empirically verified, says Park Service ecologist Craig L. Shafer, author of *Nature Reserves: Island Theory and Conservation Practice*. But in a sense, he continues, this is a minor quibble. Nobody believes that minimum viable populations will be small, or that existing reserves can contain them. Whatever the boundaries finally drawn, preserving big mammals, especially carnivores, will require Wildlands-like, multimillion-acre reserves.



SOURCE: *WILD EARTH MAGAZINE*

Room to move. To keep the Florida panther and other animals, corridors must criss-cross the state, according to Wildlands planners.

Living on the edge

At any rate, no matter what the size of the core areas, these reserves alone won't be enough. All reserves have edges and edges are anathema to conservation biologists. At the western edge of Yellowstone park, for instance, the forest ends in a sharp line caused by clearcutting. Conservation biologists argue that such edges have negative effects on species inside the forest. The brown-headed cowbird, for example, forages in open spaces but often crosses the forest edge to lay its eggs in other birds' nests. The cowbird chicks, hatching quickly, push their noncowbird nestmates over the side. According to biologists, increased habitat fragmentation has aided the spread of this nest parasite. In recent years cowbirds have effectively eliminated three forest species: the black-capped vireo, the least Bell's vireo, and Kirtland's warbler, the last now hanging on only because of a program to trap cowbirds.

Many types of human change cause edges, but conservation biologists particularly vilify roads, which act as funnels for exotic plants, expose animals to the hazards of traffic, and permit the ingress of poachers. "Edges let Bubba in to shoot endangered species," says one ecologist. "Everything within one six-pack of the point he parks is in trouble." Because one six-pack permits Bubba to travel several hundred meters, he argues, small reserves provide no haven from edge effects.

The Wildlands Project solution, buffer zones, visualizes what are in essence transition areas between pure nature and the human-dominated landscape. They would be like "the layers of an onion," as Foreman

puts it, with different types of human activity allowed in each: close to the core, benign practices such as hiking, nature study, and maintenance of a few roads; farther away, less benign practices, such as low-density housing or selective timber cutting. The buffers would filter out human activity that threatens core preserves.

No one has ever tested buffer zones. Strong land-use laws can govern the flow of human activity toward the core reserves. But there is no equivalent natural law that will prevent the core inhabitants—wolves, mountain lions, and grizzly bears among them—from finding their way out among the humans. "I don't think parents in this country will be thrilled if they had to pack a pistol when they watched their children in the back yard," says Lynn Maguire of the Duke University School of the Environment. "People do that in Alaska, and it's damned inconvenient." Some kind of buffers will be needed, she agrees, but nobody knows how to design them.

Controversial corridors

Corridors represent even more of an unknown than do buffers, leading some biologists to question their value. Like roadways between cities, corridors are intended to provide nonhumans with a transportation network. If a species goes extinct in one area, corridors may enable members from nearby patches to recolonize the empty place. Linking small populations, they could facilitate the genetic mixing that prevents inbreeding.

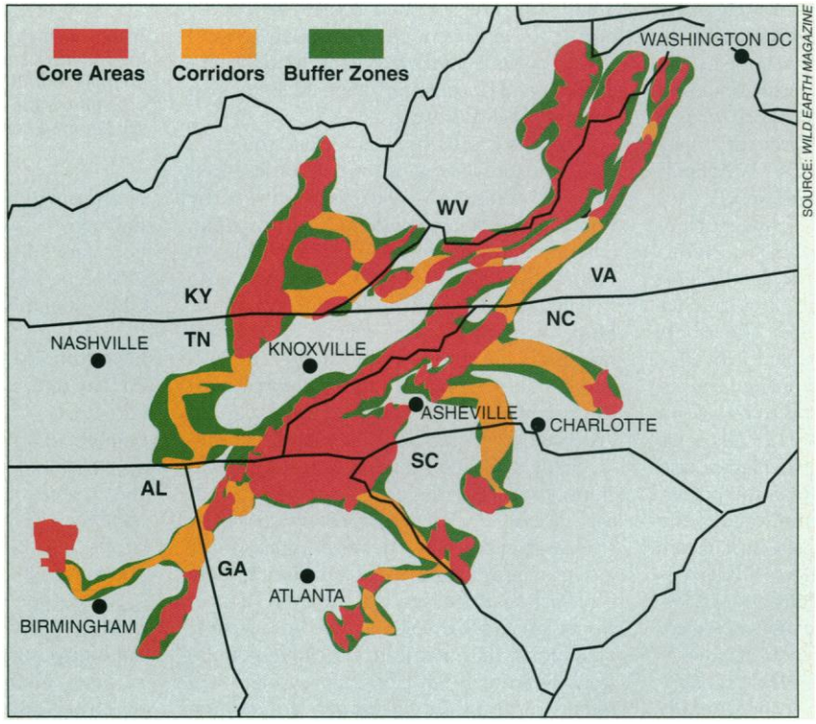
All of this depends, of course, on whether animals in nature will *use* corridors. And this is where even supporters of the concept admit there is a paucity of evidence. At a recent conference devoted to corridors, only five of 36 papers presented empirical data on their use, three of which showed that animals rarely traverse them. Nevertheless, relatively little use may be enough. In a computer simulation of a cougar population in the Santa Ana range, Paul Beier, a forester at Northern Arizona University, found that the immigration of just one or two individuals every decade strongly reduced the chance of extirpation. And he presented evidence at the Society for Conservation Biology meeting in Tempe that juvenile cougars were in fact traipsing through corridors that connected the Santa Ana range to other habitats.

Critics point out that corridors have a downside: their potential to serve as conduits for fire, disease, or introduced species. And because they are inevitably thin, says ecologist Daniel Simberloff of the University of Florida, corridors have a high ratio of edge to interior, making them relatively inimical to the species they are supposed to protect.

What is undisputed is the economic cost of corridors. Core reserves and buffer zones will be costly, of course, but they usually center on patches of undisturbed land. Connecting two such areas would necessitate crossing the land between, which is usually developed—and therefore even more costly than the equivalent amount of reserve or buffer. If limited resources are available for conservation, Simberloff asks, are corridors the best use for those resources?

Yet even scientists like Shaffer, who has doubts about some of the numbers that Wildlands is based on, contend that the whole package—core reserves, buffer zones, and corridors—is needed for complete protection. "Any particular line of analysis is not conclusive," Shaffer says, "but for every line of analysis the weather vane is pointing in the same direction. The weather vanes are pointing in the direction of large, connected, multiple populations—all of which point toward needing a network in the landscape."

Some scientists even argue that such a network may not be as disruptive as it sounds. Wilson notes, for instance, that much of upper Maine and significant portions of the Great Plains have been spoken of as land that could be incorporated into reserves. "The land is not critically needed and the population density is low," he says. "Here you're speaking of the possibility of setting aside really significant areas of natural environment that wouldn't cause major dislocation."



Range of protection. In the mid-Altantic region, the Wildlands Project proposes a vast reserve system encompassing the southern Appalachians.

Drawing the lines

Planners are listening to these arguments. Efforts to protect the Florida panther, for instance, already target land throughout the peninsula; the National Park Service is attempting to embed Yellowstone park as the center of a 20,000-square-kilometer region called the Greater Yellowstone Ecosystem; the Fish and Wildlife Service's recovery plan for the grizzly bear envisions a network of big reserves across Montana and Idaho. In some sense, the Wildlands Project is simply the first attempt to link such local efforts into a national program.

To Soulé, the scientific uncertainties should not impede action. "When you look at North America," he says, "and see the loss of roadless areas and the increasing anthropomorphisization of the landscape, you have to ask: Is this what we want? A collection of what amounts to outdoor zoos? Or do we want something more extensive?"

What Soulé wants is indeed more extensive, so extensive that it includes a moral and spiritual dimension in addition to a geographic one. Only much larger areas, he says, can preserve what he calls "wildness." Along with the conservation of biodiversity, restoring wildness is a major goal of the Wildlands Project. Wildness is difficult to define, Soulé readily concedes. Still, he says, two of its constituents are "bigness" and "fierceness." Bigness, in his view, "implies space, and space implies entire mountain ranges and entire aquatic ecosystems." Fierceness, by contrast, "implies wild animals, like wolves, moose, and wolverines." Because fierceness is involved, Soulé explains, wild areas are more than places where human beings have little impact. Wildness is "a state of nature where danger is involved because of the amount of space and the presence of large animals. Being there involves an increased probability of dying or being hurt."

Not everyone at the Society for Conservation Biology meeting endorsed these ideas.

"Frankly," drily observed Deborah Jensen, director of conservation science for the Nature Conservancy, "this whole business about wildness being fierce is a male thing." More important, she disagrees with the plan's decision to begin with current wilderness areas, which are often species-poor, rather than focussing on areas of maximum biodiversity and trying to preserve those first. The Wildlands Project, she points out, equates saving biodiversity with creating wilderness. "This [project] is talking about removing people from their homes," she says, when what is needed are better ways for people to live compatibly with the biodiversity around them.

But according to the Wildlands Project, that compatibility may simply not exist. If so, its absence will force Americans into some difficult choices. "Biologically, I agree with the Wildlands Project completely," said Fred W. Allendorf, a population geneticist at the University of Montana, who is not affiliated with the plan. "If we want to save animals like grizzly bears, we really do have to put aside the large chunks of land they're talking about. And in not doing so, as we are now, we're making the de facto choice to let them go extinct, perhaps pretty quickly. I don't know about the project's political feasibility, but at least it will help force people to make a conscious choice about what we are going to let survive."

–Charles C. Mann and **Mark L. Plummer**

Mann, a frequent contributor to Science, *and Plummer, a senior fellow at the Discovery Institute, are completing a book on biodiversity in North America.*

FUNDING PRIORITIES

Academy Recommends Global Yardstick

How can you tell whether the federal government is spending the right amount on a particular area of science? According to a new report* from the National Academy of Sciences (NAS), a key yardstick should be how well the United States measures up against the rest of the world in that field. And although the report doesn't get into specifics, some of its authors told *Science* that they believe such an analysis would not help funding prospects for areas such as high-energy physics and nuclear weapons research.

The report, written by the Committee on Science, Engineering, and Public Policy (COSEPUP) of NAS, the National Academy of Engineering, and the Institute of Medicine, proposes two goals: "that the United States should be among the world leaders in all major areas of science" and that the country "maintain clear leadership in some major areas." Although politicians should decide which fields are most important, it says, independent panels of experts should conduct periodic reviews of domestic and international trends to determine the relative strengths and weaknesses of individual fields. The report does not call for additional spending, saying that "relatively minor reallocations" of the current $75 billion R&D budget could have a "major effect" on the research enterprise.

Although the report doesn't say so, the panel informally tested the method. "We analyzed 20 fields of science and we came up with four or five that were overfunded" and some that were underfunded, says COSEPUP chairman Phillip Griffiths, director of the Institute for Advanced Study in Princeton. "None was in terrible shape," he says, "but several needed attention."

The 19-member committee did not feel that it had enough information to discuss this analysis in its report, Griffiths says, but individual panel members are not so reticent. Phillip Sharp, head of the department of biology at the Massachusetts Institute of Technology (MIT), for example, says that "we are so far ahead in high-tech armaments and other advanced weapons systems that it is ridiculous." And Robert Solow, Nobel Prize–winning economist from MIT, says that "nobody looking at the field of high-energy physics from the outside could possibly think that we need to spend more."

The report also spells out criteria to evaluate government spending on technology. It says that the country needs to be able to react quickly to technological breakthroughs such as the discovery of high-temperature superconducting materials by supporting basic research in relevant fields, maintaining the necessary infrastructure, and training sufficient numbers of new scientists. The technologies most worthy of support, it says, are those "in areas that could lead to major new industries" and in areas where U.S. industry has shown the capacity to excel and has promised to spend a significant amount of its own money.

INSTITUTE FOR ADVANCED STUDY

Taking the broad view. Phillip Griffiths, COSEPUP chairman.

Griffiths says he hopes that the report, by explaining how commercial success depends on a strong scientific base, will serve to counter arguments by those who want the government to shift money from basic to applied research. "People see our industries losing market share, environmental problems mounting, and health care costs soaring," he says, "and they wonder what purpose our investment in science is serving. We hope that this report gives policy makers a more rational way to make funding decisions" than traditional measures that are based on dollars spent or on the number of scientists funded. Its conclusions "are hardly revolutionary," admits Solow, "but they provide intelligent guidelines that a thoughtful politician might follow in deciding how to spend federal dollars on science."

COSEPUP is just the latest in a growing chorus of commentators giving opinions on why the federal government should support research. Since last fall, the National Science Foundation, the National Institutes of Health, and the White House Office of Science and Technology Policy, for example, have issued reports that address aspects of the question, and congressional leaders have likewise spoken out on the topic.

Why the sudden interest in identifying criteria for science funding? The academy decided 2 years ago that a review of the government's role in supporting research was essential given the end of the cold war, the increased international competition, and a growing dependence on science and technology for national economic progress. The $73,000 study began officially in December after Griffiths became chairman of COSEPUP.

Now the academy has spoken, but is anyone listening? Perhaps a few leaders. Last week, the committee briefed presidential science adviser Jack Gibbons and House Science Committee chairman George Brown (D–CA), and on Tuesday, Griffiths and NAS president Frank Press talked to the science subcommittee of the Senate Commerce, Science, and Transportation Committee.

At least one Senate aide is impressed, saying the report offers "an intriguing way" to decide how to invest a limited pool of federal dollars. But it's too early to say if the academy's advice will be incorporated into government policy.

–Jeffrey Mervis

* "Science, Technology, and the Federal Government: National Goals for a New Era," National Academy Press, 1993.