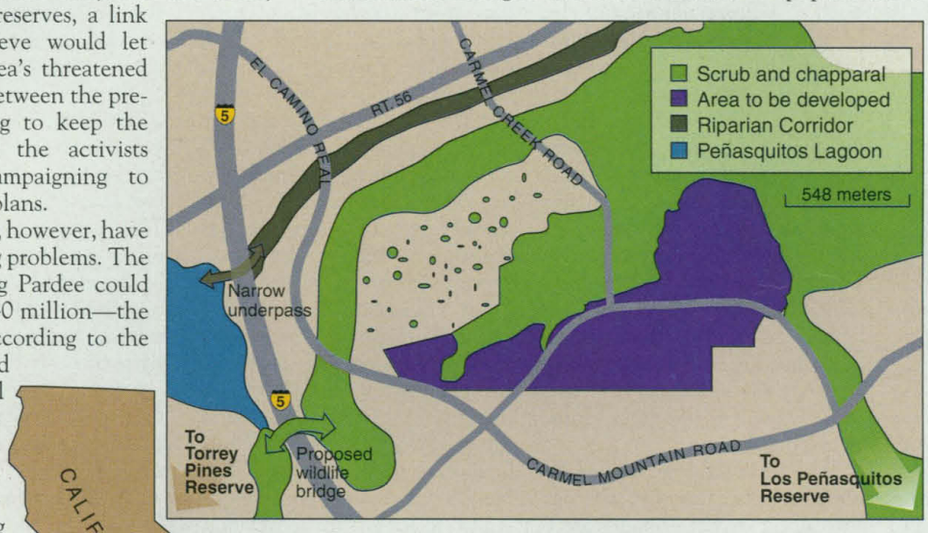
Are Wildlife Corridors the Right Path?

The popular strategy of connecting patches of otherwise isolated habitat could save many endangered species—or it could be a vastly expensive failure

Not far from La Jolla, California, lies some of the last undeveloped land left along the coast of fast-growing San Diego County. Pardee Construction, the Weyerhaeuser subsidiary that owns the central portion of the land, plans to turn it into a suburban neighborhood. But local environmental activists believe it should serve a more valuable purpose: The area forms a corridor connecting the Los Peñasquitos Canyon to the Torrey Pines nature preserves, a link that they believe would let some of the area's threatened species travel between the preserves. Wanting to keep the corridor open, the activists have been campaigning to block Pardee's plans.

Their efforts, however, have run into two big problems. The cost of stopping Pardee could be as high as $40 million—the land's value, according to the company. And the ecological value of such corridors is disputed by some of the discipline's leading researchers. Indeed, wildlife corridors have quietly become one of the most important battlegrounds in conservation, with major development projects and the future of valuable nature preserves at stake.



Path to salvation? Activists want to stop development *(purple)* to widen a corridor *(green)* between the Torrey Pines and Los Peñasquitos reserves. But some researchers say there's no evidence to support the plan.

Many ecologists and conservation activists argue that corridors are critical for maintaining biodiversity. "Connectivity is absolutely crucial," says Reed Noss, editor of *Conservation Biology*, "especially when you're talking about a species that doesn't have enough habitat in one place to maintain a viable population." As a result, big habitat-management efforts in ecological hot spots such as Florida, southern California, and the Pacific Northwest have focused on establishing these links between blocks of habitat. Corridors, Keith Hay of the Conservation Fund told *Defenders* magazine (May-June 1990, pp. 19–30), "hold more promise for the management of the diversity of life than any other management factor except stabilization of the human population."

But other ecologists worry that efforts to preserve linking areas like the one in La Jolla may be a shot in the dark. "People are encouraged to think there's a quick, easy answer—a technological fix—when there's no evidence that quick, easy answers are forthcoming," says ecologist Daniel Simberloff of Florida State University. Dennis Murphy, a conservation biologist at Stanford University who advocates careful use of corridors, agrees with this assessment, pointing to the inherent difficulty of studying complex ecological interactions in the field.

One reason for the popularity of corridors, according to Hartmuth Walter, an ecologist at the University of California (UC), Los Angeles, is that they seem to provide a "scientific" rationale for activists to preserve locally favored parcels of land: "It can always be described as a unique link that must be used to preserve connectivity, which sounds better to them than 'just preserve this land because we don't want it to be developed.' " But the result of this well-meaning application of science, he fears, may in the long run not be good for either conservation or science.

Although the notion of ecological connectivity has a long history, it did not appear in modern form until 1970, when Richard Levins, an ecologist at the Harvard School of Public Health, created the first mathematical model of what he called a "metapopulation": a set of linked local populations of a species, each in its own separate patch of habitat.

In Levins's formulation, the population of any given patch rises and falls over time; there is always a small chance that the population on any individual patch can vanish. But the empty habitats can be repopulated if the members of populations are able to disperse from patch to patch—if, that is, the metapopulation has sufficient "connectivity," a term coined in 1984 by ecologist Gray Merriam of Carleton University in Ontario. In Levins's theory, metapopulations can persist through time if the rate of recolonization matches the extinction rate.

A widely cited example is the pool frog *Rana lessonae*, which lives in ponds along the Baltic coast of Sweden. According to Per Sjögren-Gulvë of the Genetics Centre in Uppsala, the pools sometimes dry up, wiping out individual populations; when the pools refill, they are recolonized. The species stays in equilibrium, as long as it has enough pools and frogs can migrate among them. In a classic demonstration of the threat posed to biodiversity by human activity, Sjögren reported last year that the frog is threatened because foresters are draining and ditching these ponds [*Ecology* **75**: 1357–67 (1994)].

Theory becomes policy

The intuitive clarity of such scenarios has produced a rapid flourishing of metapopulation theory. In the 1980s, modeling metapopulations became what Simberloff calls a "cottage industry—there must be hundreds of papers by now." One reason for the appeal of this work, he says, is that "the models are mathematically interesting. You get these fascinating theoretical results, like multiple stable equilibria." In such situations, the range of possible states for the metapopulation is mathematically similar to the range of

possible locations for a marble on a dented sheet of metal—it can be at rest in many locations, but cannot shift easily among them.

Theory has produced policy. As ecologist Susan Harrison of UC Davis, puts it, many habitat managers now believe that a "successful [biodiversity] strategy requires conserving numerous habitat patches and the potential for dispersal between them." Corridors thus fill conservation plans in many of America's biodiversity battlegrounds. Florida has spent millions of dollars to create them, including the construction of costly tunnels under interstate highways in an effort to link tracts of land suitable for the endangered Florida panther. In Riverside County, California, the protection of corridors linking patches of habitat for the endangered Stephens' kangaroo rat was a "very important" guideline in setting up the proposed 17,400 hectares of reserves, according to the official habitat-conservation plan. In the Pacific Northwest, the U.S. Fish and Wildlife Service approved a plan offered by the timber firm Murray-Pacific covering a 22,250-hectare tract of land that houses the endangered northern spotted owl. The company gained the right to cut trees even if an owl is harmed, as long as the land itself is maintained as "dispersal habitat." On the grandest scale, the Wildlands Project—an attempt to map out a network of corridors among all of the nation's remaining undeveloped areas backed by Noss, Michael Soulé of UC Santa Cruz, and other influential conservation biologists—is intended to maintain connectivity across huge areas (*Science*, 25 June 1993, p. 1868).

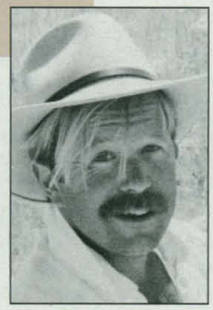
"People are encouraged to think there's a quick, easy answer ... when there's no evidence that quick, easy answers are forthcoming."
—Daniel Simberloff

Gaps in corridor research

But skeptics like Harrison and Simberloff argue that many plans to preserve corridors need closer examination. In the first place, not all species exist as metapopulations. "The phenomenon is a lot less ubiquitous than it seems," says Harrison. "Just because you see patchy habitats and blinking populations doesn't mean you have a situation where you have this balance between extinction and recolonization." And even if there are good theoretical reasons for believing the metapopulation model applies, empirical research on connectivity is extraordinarily difficult. "You have to look at an entire set of populations over the landscape over a long period of time," she says. "The amount of energy you have to have to collect the data running from patch to patch is incredible. The important processes—extinction and recolonization—are so rare that they are virtually impossible to observe."

The difficulties are illustrated in research by Ilkka Hanski and three collaborators at the University of Finland, who have conducted one of the few large-scale studies of metapopulation dynamics. The study, which took place in the Aland islands off the coast of southwest Finland, focused on the Glanville fritillary (spotted) butterfly, *Melitaea cinxia*, which breeds in small dry meadows at the end of summer. During that period, the research team repeatedly surveyed 1530 suitable butterfly meadows—some as small as 12 square meters—in an area of 3500 square kilometers. They found that neighboring populations tended to rise and fall in synchrony, suggesting that the whole area indeed held a metapopulation with many possible stable states (*Nature*, 19 October, pp. 618–621). Yet because the Finnish team has only 2 years' worth of data, Harrison cautions, the results of this "very ambitious and very exciting" study remain "compatible with other explanations" than metapopulation dynamics. The populations could be independent and the synchrony only coincidence.

"I think the burden of proof should fall on those who would deny corridors ... not on those who lobby for them."
—Dennis Murphy



Even if a metapopulation exhibits connectivity, corridors may not be needed to provide it. "When you look at populations that are naturally fragmented, they often aren't connected by corridors," says R. J. (Rocky) Gutierrez of Humboldt University in California, a wildlife biologist who has studied bird populations in the western United States. "Yet there are populations of these species on habitat islands. That's an indication that they can reach these islands independent of corridors." He points to Manhattan's Central Park as an example. "You have a good complement of [northeastern] migratory birds there," he says, "and there's no corridor connecting it" to anyplace else.

Large mammals' need for corridors is intuitively easy to understand, because they often have large home ranges or use migratory pathways. Indeed, Paul Beier, a biologist at Northern Arizona University, tracked cougars with radio collars and found that the animals always follow the same paths between patches of habitat, even paths that are kilometers long and pass through golf courses and highway underpasses. "These animals will really use corridors if they're available—even surprisingly poor corridors," says Beier. And he has some evidence that such paths are needed: "The cats will not walk through a mile of tract homes. None of the radio-tagged animals ever did that."

But even this evidence isn't conclusive. The best way to prove that organisms use corridors, Simberloff says, is to cut them off and see what happens. But in a real landscape, this is a rather difficult proposition. Beier acknowledges, for example, that he couldn't cut off all the cougars' possible corridors to see if they could still find their way across the landscape because the corridors wind through private property and under freeways. Moreover, because corridors are not always self-evident, it would be hard to know what to cut. Ted Case, an ecologist at UC San Diego, says that ecologists usually define corridors by vegetation types—strips of forest land between the lawns of suburban developments, for instance—but species such as salamanders may follow different trails. "I'm not as sure they are responding to vegetation types, rather than microbes in the soil or fungus or ants," Case says.

Finally, Simberloff also points out that corridors can have down sides. They can allow disease, predators, and exotic species to spread through a metapopulation. And corridors, which are sometimes touted as ways to increase genetic diversity among populations, may also function to decrease it, because the migration among individual populations may end up genetically homogenizing the metapopulation as a whole. Like the evidence in favor of corridors, Simberloff admits, these possibilities are largely theoretical. But, he adds, "there are examples of predators," such as eastern diamondback rattlesnakes, that use corridors for "trap-lining"—that is, lying in wait for their prey along a corridor. He also cites a 1987 study that found corridors facilitating the spread of exotic feral pigs through forest fragments in New Zealand, menacing a

genus of tree snail (in D. A. Saunders *et al.*, *Nature Conservation: The Role of Remnants of Native Vegetation*, Chipping Norton, N.S.W. Surrey Beatty, 1987).

Making trade-offs

The land between the Los Peñasquitos Canyon and Torrey Pines nature preserve exemplifies many of these issues. The area is hardly pristine wilderness. Laced with roads and suburban neighborhoods, it is bordered on the west by the eight lanes of Interstate 5, one of the most heavily traveled roads in the country. But in the middle is a relatively undisturbed mesa covered with scrub and chaparral.

Pardee's plans call for creating a development of almost 1000 homes on 160 hectares of this mesa. In exchange, the company would set aside a number of other parcels—including a wildlife corridor that snakes around the developed areas and past I-5 by way of a tunnel and a proposed bridge, forming a 3-kilometer route between the two reserves. This corridor will keep the two reserves connected, Pardee believes, and allow large predators like coyotes, bobcats, and cougars to maintain a presence in Torrey Pines, which in turn may help prevent it from being overrun by squirrels and smaller predators like feral cats and raccoons.

But corridor advocates like Soulé and Michael Beck of the Endangered Habitats League, a southern California environmental group that is spearheading the fight to protect the mesa, argue that this skinny, winding path is not enough to assure connectivity and safeguard Torrey Pines from isolation. They want to see the development on the mesa moved to the southern portion, creating a much wider corridor through the northern part and preserving much of the mesa's scrub and chaparral. And they have vowed to fight Pardee.

This is, advocates say, the only cautious and prudent course. Noss argues that in the absence of hard evidence, it is always a good idea to maintain existing connections wherever possible. And Beck, who admits there is no definitive evidence to support the mesa's use as a corridor, agrees that the best course is to be conservative. Pardee's development proposal, in his words, "is not biologically conservative at all. It takes the heart out of the mesa." He believes Pardee's needs are sufficiently flexible to allow a wider corridor.

Skeptics think corridor boosters are going to give up a guaranteed deal that will create open space in favor of an unproven scientific concept. Studies similar to Beier's, UCLA's Walter points out, suggest large mammals need no more than the narrow path called for in Pardee's current plans. Moreover, he says, the "caution" of corridor advocates actually disguises other risks. Money does not grow on trees, the ecologist says, and tapping public coffers to buy the mesa almost certainly precludes spending funds on other conservation efforts. Noting that exotic plants and other forms of degradation plague the Torrey Pines reserve—an observation that has broad scientific support—Walter asks if the area's limited conservation resources might be better spent on restoring the reserve's ecological health.

Beck worries, however, that without the biggest possible link, the degradation in Torrey Pines will only continue. "If we write off wildlife dispersal to Torrey Pines," he says, "it won't have the dynamic mechanisms that balance wildlife activity."

The debate over the corridor through the mesa, like many others around the country, must be resolved without the evidence scientists usually rely upon to settle such disputes. To Walter, it is risky for scientists to come out strongly for a concept with such uncertain empirical backing. "How are we going to get Congress to listen to biology if they think it is being used solely as an excuse to stop development?" he asks. And he worries that the result could be a discrediting of science.

Others argue that development pressure is too intense to allow researchers to work with perfect data, no matter what they do. But they disagree about what to do in the absence of evidence. "Corridors are not bad per se," says Harrison, "but there's a range of [possible conservation strategies], and you should at least consider them before blindly rushing into things." Murphy doesn't disagree, but feels that corridors should be given the benefit of the doubt. "Given what we know about the dispersal of species and the persistence of populations," he says, "I think the burden of proof should fall on those who would deny corridors to a reserve system, not on those who lobby for them."

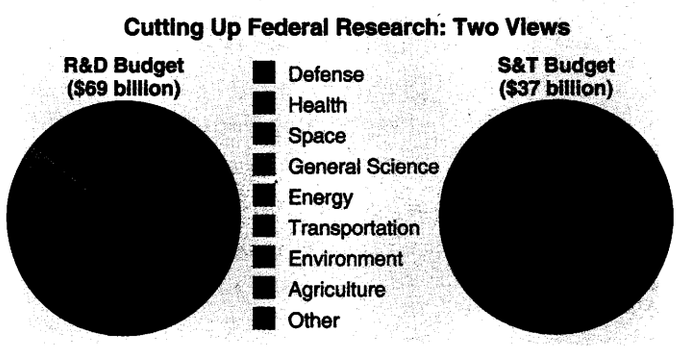
–Charles C. Mann and Mark L. Plummer

Charles C. Mann and Mark L. Plummer are co-authors of Noah's Choice: The Future of Endangered Species.

SCIENCE FUNDING

Report Strips R&D Down to the Basics

When it comes to federal spending on research, the National Academy of Sciences (NAS) hopes that less may be more. A report* released this week argues that the federal science budget is now defined so broadly that its ups and downs say little about the health of U.S. research. Instead, the academy argues, a tighter definition of R&D that includes only activities that generate new knowledge or technologies, and leaves out items such as developing new weapons and launching rockets, would provide a much sounder basis for federal policy-making. It would focus attention on the elements of the science budget most likely to keep the nation healthy and economically strong.



A healthy change. Biomedical research would become the largest component of the new S&T budget, surpassing defense R&D.

The report, written by a panel chaired by former NAS President Frank Press and discussed in a Policy Forum on page 1448, estimates that the current science and technology (S&T) budget would amount to around $37 billion under such a definition. That's a little more than half the sum the government now claims to spend on R&D. The programs not included in this total should be defended on their own terms, not for their contributions to science, the committee says.

Committee member Barry Bloom, an immunologist at Albert Einstein College of Medicine, acknowledges that some may view this new definition as implying that the country can get by with less research—"that we've sold out." But, he says, "the fact is that budgets are going down, and we're suggesting a way to protect what's most important when you don't have enough to do everything." Bloom says the committee assumed that the federal R&D budget, as it's currently defined, might shrink by 30% by 2002, and that prospect set the tone for its deliberations. By tightening the definition of R&D, he says, you can get a better sense of how core programs are faring.

The study was requested last fall by the Senate appropriations committee to help it decide how to allocate scarce R&D dollars. Funded by the National Institutes of Health, the National Science Foundation, the De-

* "Allocating Federal Funds for Science and Technology," National Academy Press, 1995.