NIEHS group, they charged, had failed to correct natural ion imbalances in the Minnesota well water. When EPA scientists repeated the experiment after adding the ions to one site's water, they say, embryos developed normally.

But at the meeting, the NIEHS's Jim Burkhart said his team also performed the assay after adding back the ions, and the embryos still developed abnormally. He and his colleagues also presented data at the workshop showing that when organic compounds and metals were filtered out of the Minnesota water, it caused fewer deformities. NIEHS toxicologist George Lucier says his group has now independently tested water from 10 affected sites and from 10 reference sites, all but one in Minnesota, and found that the deformities appear only in water from the affected sites. "It's something in the water," concludes Lucier, adding that it's too early to say whether that something is natural—such as a plant steroid—or synthetic, such as a pesticide.

Some observers wonder whether the scale of the problem has been overblown. Experts note that naturalists have been reporting five-legged frogs and salamanders for at least 250 years. Yet it is difficult to know how common these abnormalities were in the past because museum collections tend to keep only scientifically interesting or pretty specimens. Without long-term monitoring, "there's virtually no way to figure out what the background levels are," says Smithsonian Institution ecologist Jamie Reaser.

Indeed, some ecologists suspect that normal predation attempts could spawn high background levels of deformity. Reaser says that in her fieldwork, she often notices tadpoles damaged by aquatic predators: "chunks taken out of tails, eyes damaged, legs damaged." Sessions adds that he has found that bullfrog tadpoles bred in cramped quarters will nibble off each other's limbs. As for the 1600-and-counting confirmed abnormalities since August 1995 compiled so far by the North American Reporting Center for Amphibian Malformations (www.npwrc.org/narcam), "I will not be surprised at all if it turns out this has been an enormous Chicken Little thing," says Sessions.

However, David Gardiner, a developmental biologist at the University of California, Irvine, disagrees. He recalls a family whose Minnesota farm he visited to collect water. As he was leaving, Gardiner says, a teenager remarked that his family is still waiting for an explanation. They are justifiably worried, he says, and "they'd like to figure this out." But that answer may be a long time in coming. Solving this puzzle, predicts Wake—who thinks multiple causes are at work—will be "a scientific nightmare."

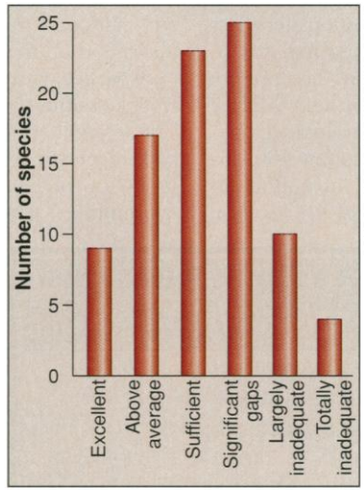
**–Jocelyn Kaiser**

ECOLOGY

# Qualified Thumbs Up for Habitat Plan Science

SANTA BARBARA, CALIFORNIA—For 2 months earlier this fall, University of Washington, Seattle, grad student Amanda Stanley sifted through reams of documents—from dense scientific articles to denser federal reports—bearing on the fate of northern spotted owls, marbled murrelets, and other imperiled icons of the Pacific Northwest. Her task was to assess the quality of the science underpinning the state of Washington's 1996 plan to protect these species while allowing some logging on the state's land. Sound like a nightmarish grad school assignment? "I had no idea what I was getting into," Stanley admits.

The slogging was no mere academic exercise: Stanley was one of 106 grad students from eight universities who played a role in one of the most unusual ecological studies ever undertaken. Led by Peter Kareiva of the University of Washington and 12 other ecologists, the students last week completed an initial assessment of the science behind a divisive environmental policy tool: habitat-conservation plans (HCPs), agreements that allow developers to harm endangered species in return for specified efforts to protect habitat.




**Critics rebuffed?** HCPs did better than some assert at addressing habitat loss and other threats to species.

A growing chorus of environmentalists and scientists has argued that many HCPs—usually drafted by scientific consultants hired by landowners—are flawed and effectively promote extinction (*Science*, 13 June, p. 1636). But at a meeting here last week at the National Center for Ecological Analysis and Synthesis (NCEAS), Kareiva's group offered a different view: HCPs are far from the junk-science giveaways to developers depicted by their harshest critics. Although the group also reported that the plans are frequently plagued by inadequate monitoring and a lack of key data, the analysis puts HCPs in a better light. "What did surprise me," says meeting attendee Ron Pulliam of the University of Georgia in Athens, "was how well the science was used when it was available."

Created by a 1982 amendment to the Endangered Species Act (ESA), HCPs are meant to resolve conflicts between conservation and commercial interests. Because the ESA generally forbids harming listed species, it has led to frequent clashes between property owners and the U.S. Fish and Wildlife Service (FWS), which administers the act. The amendment gives landowners some leeway by allowing FWS to issue a permit for activities that harm a listed species. To receive a permit, developers must devise an HCP that will, "to the maximum extent practicable, minimize and mitigate the effects" on endangered species. The amendment was rarely used during the Reagan and Bush years; by 1992, only 11 HCPs had been signed.

That has changed. Since taking office in 1993, U.S. Interior Secretary Bruce Babbitt has championed HCPs, arguing that the amendment was the key to avoiding "environmental train wrecks" over endangered species. To make HCPs more attractive to landowners, Babbitt unveiled a "no surprises" policy 3 years ago, promising that "unforeseen circumstances"—for example, species being added to the endangered list that might trigger new protective steps—would generally not force modifications to existing HCPs. When a draft Senate ESA reauthorization bill with this change appeared last February, scientists and environmentalists were galvanized into scrutinizing the burgeoning HCP program, which now numbers more than 200 plans.

Most observers didn't like what they saw. The opening salvo came last April from nine well-known conservation biologists, led by Dennis Murphy of the University of Nevada, Reno, who charged that "many recent HCPs have been developed without adequate scientific guidance." A National Audubon Society task force drew similar conclusions soon after, claiming that a "disturbing number of HCPs are based upon questionable or risky scientific assumptions." The Administration, meanwhile, had few data supporting its rosier view. At a meeting on HCPs last April sponsored by the Environmental Defense Fund (EDF), Babbitt asked scientists to offer improvements to these controversial compromises.

One attendee was Frank Davis, deputy director of the NCEAS, an ecological think tank at the University of California (UC), Santa Barbara. The center has an unusual mission: Instead of sponsoring experiments, it tries to resolve important ecological questions by analyzing existing data (*Science*, 17 January, p. 310). Believing that a synthesis of HCP data fit its mission, Davis urged the center to support a study, which it agreed to do with the American Institute of Biological Science (AIBS).

To lead the effort they tapped Kareiva, who is well known for applying sophisticated mathematical modeling to ecological problems. Kareiva had no previous involvement in the politically charged subject of HCPs. "He was not identified with any one position," says AIBS President Frances James, an ecologist at Florida State University in Tallahassee. "He fit the bill."

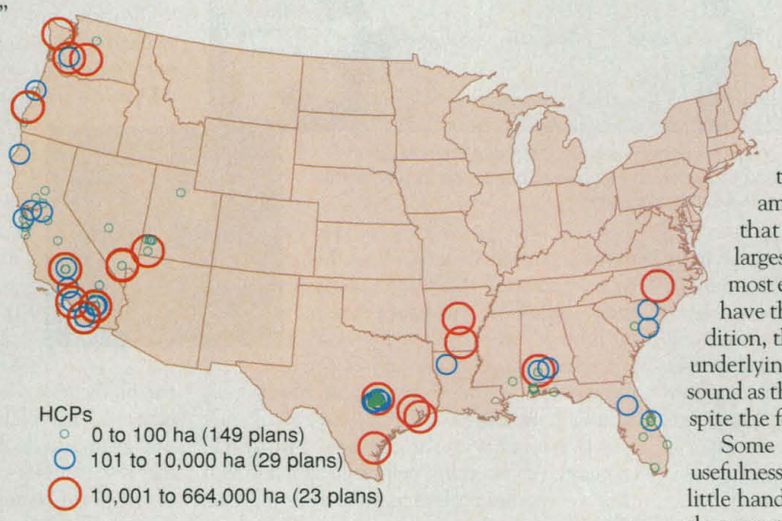
Kareiva soon discovered—to his shock—that FWS has no central repository of HCP documents. Getting data from far-flung agency offices, consultant firms, and environmental groups would be a major project in itself. Rather than ask senior ecologists to embark on a grinding paper chase, Kareiva decided to marshal an army of grad students: "grassroots science," as he calls it.

Last August, he contacted colleagues at eight universities—UC Berkeley, Florida State, North Carolina State, UC Santa Barbara, UC Santa Cruz, Virginia, Washington, and Yale—with a novel proposition: Would they conduct a graduate seminar that would produce a major analysis of an urgent scientific issue—by Christmas? The ecologists, he said, quickly "put up notices in the hallways," attracting scores of eager students.

After reconnoitering 206 HCPs, Kareiva's team of senior ecologists selected 44 for indepth analysis in late September, choosing a range of sizes, locations, and landowner types. Next, they divvied the plans among the universities and created a form with hundreds of questions for assessing each plan. The questionnaire covered the plans' designs, not their implementation. The students, after becoming familiar with the HCP process, spent the rest of their seminars evaluating plans based on official documents, scientific literature, consultants' reports, expert opinions—whatever they could lay their hands on.

They were asked to weigh the scientific evidence behind four key aspects of an HCP: the overall health of a species' population; the extent to which a species would be "taken"—harmed or killed—by an activity allowed under an HCP; how this taking would affect a species' long-term viability; and the actions prescribed to mitigate harm. They also evaluated any long-term monitoring, by the landowner or a government agency, spelled out in an HCP. "By the end of the seminar," says Yale seminar leader David Skelly, the students "were pretty sophisticated" at evaluating HCPs.

Questionnaires completed, the students converged on NCEAS earlier this month. Kareiva gave them less than a week to merge the data sets, produce descriptive analyses, summarize major findings, and begin writing papers for publication and a "gray literature" report as a source book for further work.




SOURCE: NCEAS/HCP WORKING GROUP

**Territorial gains.** More than 200 HCPs are now in action, with another 200 in the works.

On 9 December, the students presented their findings to a small, invited audience of biologists experienced with HCPs. Few attendees were startled to hear that the plans' authors had been hampered by a lack of data. For example, marbled murrelets are covered in several Pacific Northwest HCPs, yet there are few data available to estimate the number of birds harmed by an activity such as logging.

The big surprise was how well the HCPs were perceived to have used available data. Two-thirds of the plans, the students judged, were able to determine reliably a population's health before implementation. About half the plans made a reasonable guess as to the harm the landowners would cause species (although the Kareiva team's study did not evaluate what actually happened). And half adequately gauged primary threats, such as habitat loss, to species (see graph on facing page).

But many plans had serious shortcomings. Nearly two-thirds were deemed "insufficient" to determine how the actions allowed by an HCP would affect species' viability as a whole, rather than merely the local population in the plan. In 60% of HCPs, the monitoring was inadequate, because either the plans were poorly crafted or the students couldn't tell from the documents whether the monitoring was sufficient. And again and again, the students lamented the absence of basic natural history on organisms covered by HCPs.

The work groups uncovered a few horror stories; prime examples were two HCPs covering the Utah prairie dog. In both cases, property owners were allowed to build on habitat if they relocated the prairie dogs to public land. Scientists had long known, however, that relocation fails—only 3% of prairie dogs survive such a move. Still, FWS approved the plans because relocation was the agency's own strategy for recovering the species.

Overall, the analysis offers some "counterintuitive surprises that will make us think," says Mike Scott of the U.S. Geological Survey's Biological Resource Division, formerly the National Biological Service. He cites, among others, the puzzling finding that medium-sized HCPs—not the largest ones, which generally are the most elaborately prepared—appeared to have the best scientific grounding. In addition, the analysis found that the science underlying multispecies plans seemed as sound as that behind single-species ones, despite the former's greater complexity.

Some observers, however, question the usefulness of an assessment by scientists with little hands-on HCP experience. "You simply cannot do this kind of evaluation if you have not been on the ground trying to put these plans together," says Nevada's Murphy, the only HCP critic invited to the meeting. According to Murphy, HCPs "are essentially political documents" that should not be evaluated by questionnaire.

To give other HCP critics and proponents alike a chance to review the analysis, Kareiva hopes to have it posted on the NCEAS Web site (www.nceas.ucsb.edu) by the end of March. By then, Congress may have renewed its debate over ESA reform, and the students' data could "become a focus of analysis and discussion," Kareiva says, "getting us away from silly ideology and storytelling." But even if politicians ignore the data, EDF's David Wilcove believes the effort will have produced a benefit: "100 grad students and 20 professors who know a lot more about HCPs than they did before." He adds, "I don't know whether they found the project inspiring or a never-to-be-repeated nightmare, but I hope they'll stay interested."

**–Charles Mann and Mark Plummer**

*Mann and Plummer are co-authors of* Noah's Choice: The Future of Endangered Species.