Africa, and the indigenous inhabitants of North America's Great Basin, net hunting provided a safe way of snaring mammals as large as deer and mountain sheep. Men, women, and children all worked together as beaters, frightening the animals with loud noises and driving them in the direction of the nets. "Everybody and their mother could participate," says Soffer. "Some people were beating the underbrush; others were screaming or holding the net." Once the prey was caught in the mesh and safely immobilized, the hunters dispatched it with clubs and other weapons.

Accounts also show that many historical hunters and gatherers mounted such drives to amass food for large seasonal and ceremonial gatherings. This fits closely with evidence from Dolni Vestonice and Pavlov. "As best we understand these sites now," says Soffer, "[they] are aggregation sites where people are getting together in fairly large numbers." Likely occupied throughout the cold season, the sites reveal many traces of Paleolithic ceremony, including clay Venus and animal figurines that appear to have been ritually destroyed.

Adovasio, Soffer, and Hyland also suggest that net hunting may explain the most distinctive features of the Gravettian phase. Other researchers have long believed that the large populations, increasingly settled life, and complex technology of this phase was supported by extensive mammoth hunting. Soffer and her colleagues agree that Gravettian males sometimes hunted mammoths and other large game with spears, but they now argue that communal net hunting—capable of reaping huge windfalls of food regularly at very low risk of injury to human participants—may have been the key development.

Other Paleolithic experts are intrigued by this new hypothesis. "I don't see why it shouldn't be," says Desmond Clark, a professor of anthropology at the University of California, Berkeley. But the challenge, adds Clark, will be to find evidence of nets and textiles at other Gravettian sites.

Soffer will be following these efforts with keen interest. After all, she explains, net hunting could hold the key to many puzzles, including the evolution of modern human anatomy: "When you look at the beginning of the Upper Paleolithic, the men are really hunky. But when you look at them after 20,000 years ago, they get smaller and weaker. The strong ones are not being selected for." While many of her colleagues have related this change to the advent of spear throwers or bows and arrows, which reduced the need for physical strength, Soffer favors another hypothesis. "I think net hunting contributes to it," she concludes. "You don't need brawn to do it."

–Heather Pringle

Heather Pringle is a writer in Vancouver, Canada.

ECOLOGY

How Humans and Nature Influence Ecosystems

ALBUQUERQUE, NEW MEXICO—More than 3000 ecologists and conservation biologists met here from 10 through 14 August for a joint meeting of the Nature Conservancy and the Ecological Society of America on the theme of natural and human influences on ecosystems. Talks included discussions of tropical forest burning, endangered prairie chickens, and alien weeds.

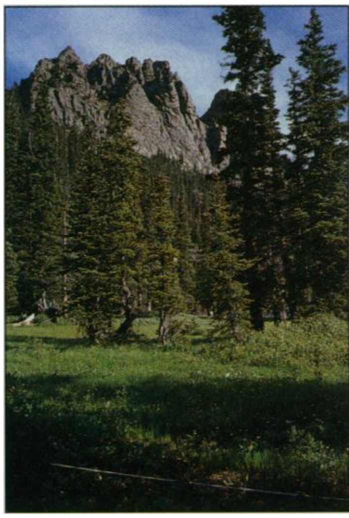
Does Diversity Lure Invaders?

Exotic weeds like Japanese kudzu and European wild oats have swept over ecosystems from Florida to Australia. Indeed, many biologists consider continent-hopping alien species the second most important threat to biodiversity after habitat destruction. There has been at least one reason for optimism, however: Ecologists have long assumed that diverse landscapes should be more resistant to exotic plant invaders, as their array of species does a better job of using up all the available resources like nitrogen and sunlight. But new studies described at the meeting suggested that diversity isn't always a shield against invasions.

In one provocative talk, researchers who examined several landscapes in the U.S. Midwest and the Rockies found that areas that are hot spots of plant biodiversity are sometimes magnets for invading weeds, perhaps because good growing conditions favor both native species and exotics alike. Another talk, an analysis of global patterns of plant invasions, described similar results and pointed up the importance of external factors in invasions, such as how often seeds are introduced to a landscape by human visitors.

The expectation that species-rich ecosystems should be resistant to invasions stems from a notion (see p. 1260) that diversity goes hand in hand with ecological productivity and stability. That idea has been controversial, and so has the question of whether diversity wards off exotic invaders. Thomas Stohlgren of the U.S. Geological Survey's (USGS's) Biological Resources Division and colleagues at Colorado State University in Fort Collins decided to revisit the problem by looking at the numbers of native and exotic species in two biomes—temperate grasslands and mountains. The researchers counted plant types and the amount of cover in 180 1-meter-square plots in four types of prairies in the western United States and also in 200 plots in two forest and two meadow types in the Colorado Rockies.

In the prairies, the team found that the more diverse 1-square-meter plots did contain fewer exotic weeds, but the opposite was true in the 1-square-meter plots in the Rockies. When the researchers examined their data on a larger scale—a set of plots within a total area of 1000 square meters—they found that exotic invaders were more numerous in more diverse areas in both biomes. At that scale, Stohlgren says, one sees "patches of invasion and high diversity in a sea of low diversity."



Ripe for invasion. Alien weeds are turning up in the species-rich Rockies.

Stohlgren, whose results are in press in *Ecology*, noted another feature of the more diverse areas that could explain why they have so many invaders: They also had higher levels of nutrients such as nitrogen and carbon and tended to support denser foliage. Stohlgren believes that resource availability—which sometimes correlates with diversity—may explain the exotics' success. "Native plants and exotic plants like the same things—light, soil, water—the good life," Stohlgren says.

Stanford's Peter Vitousek says he doesn't think Stohlgren's result rules out the possibility that in some systems, diverse areas are more resistant to invasion. He adds, however, that "the argument that the effect of resource availability can be more important than diversity is original and useful." And David Tilman of the University of Minnesota, St. Paul, whose own experiments in grasslands have found that diverse plots are less susceptible to invasion, is intrigued that the relationship Stohlgren found held up across several kinds of meadows and forests in the Rockies. This suggests diversity doesn't protect against invasions "across biome types," Tilman says, and that "other factors now determine the chance it will be invaded."

Additional support for Stohlgren's findings came from an analysis described by Mark Lonsdale of the Australian Commonwealth Scientific and Industrial Research Organisation at a separate symposium. Lonsdale explored the relationship between diversity and exotic species in data from 162 sites worldwide, representing many different biomes. Like Stohlgren, Lonsdale found that species-rich biomes tended to have more exotic species, with temperate zones being most invaded and savannahs and deserts least.

Lonsdale also found that there were more exotic species in nature reserves that have a lot of visitors, suggesting that how often exotic seeds are introduced is as important as the growing conditions in the new territory. "It seems obvious, but it hasn't seemed to enter the scientific consciousness before now," Lonsdale says. Another key factor appeared to be cultivation. In Australia, Lonsdale found that at least 46% of noxious weeds were intentionally introduced for produce or as ornamentals. Similarly, in tracing back the origins of about 2400 naturalized species in the United States, Richard Mack of Washington State University in Pullman estimated that at least two-thirds were deliberately introduced or were contaminants in batches of imported seeds.

–Jocelyn Kaiser and Richard Gallagher

A Nasty Brew From Pasture Fires

Scientists studying global climate change are keeping a sharp eye on what's happening in the tropics. Slash-and-burn land use there pumps out an enormous amount of carbon dioxide and other greenhouse gases each year—adding up to an estimated 1.6 million metric tons of carbon, or about 23% of the total produced by human activity worldwide. But one talk at the meeting made clear that slash-and-burn farmers do far more burning than researchers had thought after they clear the primary forest. The extra burning sends into the skies a witch's brew of noxious pollutants as well as more greenhouse gases.

Ecologist Boone Kauffman of Oregon State University in Corvallis described some of the most precise studies yet of the carbon balance in a patch of Amazonian rainforest when it's burned to create a pasture. To do these studies, the Oregon State team first had to establish a baseline by assessing how much biomass a forest contains. Carbon cycle modelers typically rely on forest wood inventories conducted only to tally larger marketable trees. To find out how much biomass a forest really holds, the Oregon State researchers wrap tape measures around trees, weigh dried grasses, measure downed logs, and sample soil nutrients. "It's brute force science that needed to be done," says David Schimel of the National Center for Atmospheric Research in Boulder, Colorado.

As Kauffman reported at the meeting, the group's latest fieldwork has revealed an overlooked pollution source: repeated burning of Amazonian pastures that have already been subjected to one slash-and-burn episode. Modelers have assumed that once the primary forest had been burned for a pasture, the only additional carbon released came mainly in the form of carbon dioxide from decomposing biomass. But when Kauffman studied over 18 forest and pasture fires in Rondonia and Pará states in Brazil between 1991 and 1995, he found that farmers burn the fields again every couple of years to get rid of weeds and spur the growth of grasses. In a typical decade, almost as much vegetation and dead wood is burned off existing pastures as was originally burned to create them. The burning releases not only extra carbon dioxide but also soot, nitrogen oxides, and nonmethane hydrocarbons, among other harmful compounds. "We get a lot more pollutants that have deleterious effects on global change, human health, and ozone depletion," Kauffman says. "That has not been considered in the [climate] models."

B. KAUFFMAN

Up in smoke. Amazon deforestation produces more air pollution than researchers thought.

Schimel says it's too soon to say whether the additional burning actually boosts the warming effect of greenhouse gas emissions from the tropics. For one thing, he says, the new growth that takes place after each episode of reburning draws carbon out of the atmosphere again. Also, the soot forms aerosols that might cool the atmosphere.

Answers will also come from the Large-Scale Biosphere-Atmosphere Experiment in Amazonia, a $50 million, 4-year international project led by Brazil getting under way next year. It will team up hydrologists, atmospheric chemists, ecologists, and plant physiologists to get a better handle on carbon losses from land uses in the rainforest. **–J.K.**

Fingering a Genetic Bottleneck

Biologists hoping to spur the recovery of endangered animals in the wild may face a big obstacle: The remaining population may have lost genetic diversity. A meager gene pool after years of inbreeding could help explain the poor reproductive success of, for instance, the Puerto Rican parrot, African cheetahs, and the Florida panther.

But biologists haven't always agreed on whether a population has truly lost genetic richness because they can't compare the DNA of surviving animals to that of their ancestors. In one talk, however, researchers at the University of Illinois, Urbana-Champaign, described how they managed to do just that. The group directly documented loss of genetic diversity in an imperiled species—greater prairie chickens in Illinois—by comparing DNA from decades-old museum specimens with that of prairie chickens today. The result is "potentially one of the clearest examples we have" of a genetic bottleneck in an endangered species, says population geneticist Bob Lacy of the Chicago Zoological Society.

Prairie chickens numbered in the millions in Illinois in the 19th century, but, largely due to habitat loss, only 50 were left by 1993 on a state reserve. To find out what had happened to the gene pool of these birds, evolutionary ecologist Juan Bouzat and colleagues Harris Lewin and Ken Paige compared six DNA markers, called microsatellites, from genetic material from the feather roots of 15 Illinois birds collected by museums in the 1930s and 1960s with the same DNA markers in the modern Illinois prairie chickens. They also examined these markers in populations in Kansas, Minnesota, and Nebraska, where the birds still number in the thousands. The modern-day Illinois chickens had clearly gone through a bottleneck: Their DNA had roughly half as many variants of these markers as the DNA from the museum specimens, and some of the variants had been lost "forever," Bouzat says. The populations in the other three states were in better shape. They had about the same amount of diversity as the museum specimens.

Lacy, who wasn't at the meeting but is familiar with the research, cautions that the study doesn't prove that lack of diversity is harming the Illinois birds, which have a low rate of reproduction. But Bouzat says other data comparing the birds' breeding success with that of chickens in the 1960s suggest that genetic factors are involved in the decline. Lacy adds that if similar studies can provide other clear-cut cases of genetic bottlenecks, they will influence controversies such as one involving the Florida panther. Biologists disagree over whether the panther's reproductive problems result from mercury poisoning or genetics. "They've come up with a highly instructive case," Lacy says. **–J.K.**