Bees From the Rainforest Add Up To a $62,000 Coffee Buzz

PORTLAND, OREGON—A record number of ecologists—more than 4000—gathered here from 1 to 6 August for the 89th annual meeting of the Ecological Society of America (ESA). They discussed everything from ecosystem services to invasive species to fire ecology.

In recent years, some economists and conservation biologists have tried to estimate the monetary value of natural ecosystems to people. In the best-known example, ecological economist Robert Costanza of the University of Maryland, College Park, and his colleagues calculated in 1997 that the planet's "ecosystem services"—air and water purification, nutrient cycling, waste decomposition, and more—are worth $33 trillion per year, an amount nearly twice the global gross domestic product. And in 2002, a team led by conservation scientist Andrew Balmford of the University of Cambridge, U.K., calculated that a worldwide network of nature reserves would be worth roughly $5 trillion, 100 times the value of exploiting the resources in them (*Science*, 9 August 2002, p. 950).

Bee profitable. Pollination from nearby bees is worth $62,000 to a coffee farmer.

Such global estimates, however, have little meaning to the farmer, rancher, industrialist, or city planner who makes land-use decisions based on considerations closer to home. So a team led by Taylor Ricketts of the World Wildlife Fund tackled a discrete local example. Their answer may help save patches of rainforest.

The researchers homed in on a single coffee plantation in Costa Rica and measured the value of one ecosystem service, the pollination of the coffee crop by bees. Ricketts's team examined 11 bee species that visited coffee flowers from stands of rainforest that bordered the farm. Flowers near the forests received twice as many bee visits and twice as much pollen deposition as did flowers far from forests, they found. As a result, coffee plants near the forests had 20% greater yields and 27% fewer deformed beans. Combining these data with market prices for coffee, the team calculated that bee pollination accounts for $62,000, or 7%, of the farm's annual income. In addition, by providing multiple species of native bees, the forest patches served to stabilize pollination services year to year against the severe population fluctuations typical of feral honeybees.

Just looking at the benefit from pollination, the value of preserving the natural forest stands is greater than the value of cutting down the forest for other uses, Ricketts told ESA attendees. For instance, cattle grazing would yield only $24,000 per year.

The team's full cost-benefit analysis appears in the *Proceedings of the National Academy of Sciences* online on 11 August and in the upcoming issue of *Conservation Biology*. Ricketts and his colleagues plan to return to Costa Rica this winter to spread word of their findings among coffee farmers, government officials, and agricultural extension agents.

The bee study "provides a tangible example of the benefits of [forests] in a way that's immediately relevant to the coffee farmers," Balmford says. "The key to getting ecosystem services on the table for decision-making is to begin to quantify them in a locally relevant way."

Are Invasive Species Born Bad?

Honoring the bicentennial of Lewis and Clark's expedition through the newly acquired western territories, the official theme of this year's ESA meeting was the ecological exploration of inhabited landscapes. Based on the number of presentations, however, it might have been a conference devoted to invasive species.

One key question for ecologists is what makes these interlopers so invasive. Do certain species simply have an innate potential to grow and reproduce rapidly? Or does invasiveness result from evolutionary changes that occur after an introduction? As ecologist Kristina Schierenbeck of California State University in Chico puts it, "Are invasive species 'born' or 'made?' "

Most ecologists have long assumed that invasiveness was just a matter of being in a favorable environment. If an organism introduced into a new region leaves behind its natural predators, competitors, and parasites, its chances of reproductive success increase. Recently, however, ecologists have explored whether species may also evolve to become invasive in their new homes. This "evolution of increased competitive ability" (EICA) hypothesis, proposed in 1995 by ecologists Bernd Blossey and Rolf Nötzold, is just now being tested rigorously.

The meeting showcased "very compelling examples and evidence that EICA can occur," says ecologist Dana Blumenthal of the U.S.D.A. Agricultural Research Service in Fort Collins, Colorado. But "the jury is still definitely out" on the extent of the phenomenon, he adds.

The EICA hypothesis predicts that once an organism escapes its natural enemies, it no longer needs the defenses it had evolved against them. If these defenses use up precious energy or resources, natural selection should favor the organism investing instead in traits that give it a competitive edge over its new neighbors. For a plant, this could mean larger size, faster

Less is not more. Using fewer resources for defenses doesn't enable St. John's wort to grow faster in the United States.

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growth, or greater reproductive capacity, all adding to its invasive nature.

Evidence for EICA was offered by Evan Siemann and William Rogers of Rice University in Houston, Texas, who work with the Chinese tallow tree, *Sapium sebiferum*. They have found that trees from introduced southern U.S. populations show faster growth and reduced investment in chemicals that defend against leaf-eating insects compared with trees from native Asian populations. As with most EICA studies, the work featured "common garden experiments," in which native and introduced plants are grown side by side to control for environmental variables. The investigators found that Asian trees outperform American trees in settings with native Asian herbivorous insects, whereas American trees outperform Asian ones in settings without these insects. Many scientists, Blumenthal says, consider this evidence the strongest so far in support of the EICA hypothesis.

However, a study of the European plant garlic mustard, *Alliaria petiolata*, which arrived in North America 150 years ago, failed to support the hypothesis. Experiments presented by Oliver Bossdorf of the UFZ Centre for Environmental Research in Halle, Germany, and colleagues did show that American populations had lost their resistance to a European weevil that specializes on the plant. But when the group then grew American and European populations in side-by-side competition, plants from native European populations outgrew those from introduced American populations.

Perhaps the most extensive common garden experiments thus far involve St. John's wort, *Hypericum perforatum*, the plant of alternative medicine fame, which was introduced from Europe to America 2 centuries ago. Ecologist John Maron of the University of Montana, Missoula, and his colleagues collected seeds from 50 St. John's wort populations across Europe and North America and then grew European and American plants in common gardens on both continents. Maron's group then measured levels of three chemicals the plants make to deter insects. The American plants exhibited lower levels of the chemicals, indicating they had lost defenses since their introduction. When grown in Europe, the American plants also suffered more infection and mortality than the natives, revealing that the apparently weakened defenses did have a real effect.

Did the American plants that saved on defense invest their new gains into competitive ability, as the EICA hypothesis predicts? Apparently not. The American plants showed no trend toward larger size or greater reproductive ability when growing in the United States.

Maron's work tested EICA more comprehensively than any previous study, according to some ecologists. "He did exactly the experiments that needed to be done," says Marc Johnson of the University of Toronto.

Maron doesn't perceive his results or those of Bossdorf's group as undermining EICA, however. He says that circumstances will vary for every species. Indeed, in Portland, both Blossey and Blumenthal summarized previous tests of the EICA hypothesis and found that of 14 studies, five supported EICA, one rejected it, and the remainder were inconclusive. "One flaw of EICA," says ecologist Peter Kotanen of the University of Toronto, "is that it envisions a very simple tradeoff between defense and growth. The real world is more complicated."

Nonetheless, the ongoing rigorous assessment of the hypothesis demonstrates that the study of invasive species has come of age. "What I found striking at this meeting is how much invasion biology has matured," says Kotanen. "We've gone from case histories and compilations to people finally doing experiments, and we've probably learned more in the last 10 years than in the 5 decades before."

Fighting Sudden Oak Death With Fire?

Fire rescue. Sudden oak death (on the leaves of a California bay plant) is less prevalent in areas that have burned (red on map).

One of the most destructive invasive species these days is the water mold *Phytophthora ramorum*, the pathogen that causes sudden oak death (SOD). The suddenness with which it began ravaging trees in California's oak woodlands just a decade ago led researchers to suspect that it was introduced from elsewhere, although no one yet knows for sure.

What is certain is that SOD threatens to drive several oak species into oblivion and profoundly alter the landscape of these woodlands. And the oak forests of eastern North America, where red oaks are known to be susceptible, could be next. The meeting, however, offered some possible good news for SOD researchers: Controlled fires might just provide a way to limit the spread of the troublesome pathogen.

Fire ecologists Max Moritz of the University of California, Berkeley, and Dennis Odion of the University of California, Santa Barbara, collected data from state agencies on the pathogen's presence at different sites in California, as well as historical data on forest fires. They discovered that the disease was much less prevalent in areas that had burned since 1950. "You almost never see infections in [those] areas," says Moritz. One reason, he and Odion speculate, could be that plant defenses against pathogens become weaker in older, unburned stands; trees need to invest more in competition with neighbors as stands age, and production of some defensive chemicals declines in older plants, for instance.

Whatever the mechanism, the findings indicate that California's fight against forest fires over many decades may have precipitated or accelerated the SOD outbreak. However, the findings also suggest that controlled burning might help halt the disease. Moritz and Odion warn that careful experiments would be needed to determine whether prescribed burns have the desired effect.

The rapid spread of SOD is "such a dynamic system that a lot of our tools in ecology for understanding and predicting patterns are inadequate," says Richard Ostfeld of the Institute of Ecosystem Studies in Millbrook, New York. That's why the fire findings, he adds, are "both interesting and important" for battling the disease.

–JAY WITHGOTT

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