others—often the government. What's more, the government effectively discourages lower-input practices like crop rotation and reduced chemical use through its farm subsidy system, most observers agree. The federal government pays most subsidies in the form of per-bushel price supports, which historically have encouraged farmers to pile on the fertilizer and pesticide to boost yields. In addition, government programs support only a handful of crops, including wheat, corn, and cotton. Farmers who expand their rotations to include soil-saving crops like alfalfa and clover thus give up much of their subsidy check. "When I'm in a bad mood, I say the United States likes corn more than it likes farmers, because it supports corn and it doesn't support farmers," grouses Iowa State University agricultural economist Mike Duffy.

Changes made in the 1990 farm bill and other legislation have broadened farmers' crop choices somewhat, Duffy says, but subsidies still favor high-input agriculture and its favorite crops. Faeth suggests leveling the field by making farm subsidies independent of which crops a farmer grows. This would clear the way for farmers to choose techniques based on their costs and benefits without the distorting effect of selective subsidies. To encourage even further reductions in environmental costs, Faeth says, the government could offer subsidies that actively reward land stewardship. Indeed, the present Conservation Reserve Program, which pays farmers to take erodible cropland out of production, will prevent billions of dollars in erosion damage, according to Ribaudo's estimates.

Even without major policy changes, however, the gap between conventional agriculture and its sustainable alternatives has narrowed gradually over the past few years as mainstream farmers recognize and adopt individual lower-input practices that prove to save money. "What we used to call conventional agriculture in Iowa is pretty much sneered at by the conventional farmer today," says Dennis Keeney, director of Iowa State University's Leopold Center for Sustainable Agriculture. "Very few of them plow anymore. Conservation tillage and cutting back on chemical use are becoming bragging points in coffee shops." Relatively few farmers are likely to buy the whole sustainable agriculture package any time soon, especially in the productive heart of the Midwest. But as research expands the repertoire of alternative techniques and—perhaps most important—as farmers grow comfortable with what were once unorthodox approaches to cropping, mainstream agriculture seems certain to continue its piecemeal absorption of sustainable methods.

–Bob Holmes

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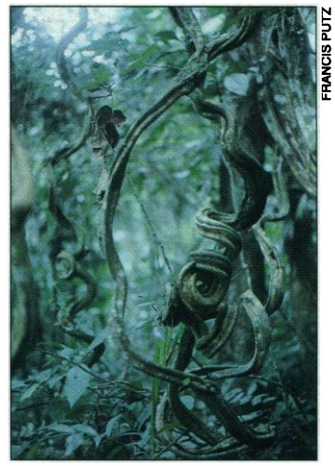
FORESTRY

How to Make the Forests of The World Pay Their Way

Almost all biologists agree that the world's forests are in trouble. Despite a decade of intense international attention to the problem of deforestation, 17 million hectares of forest in Central and South America, Asia, and Africa are vanishing each year, up from 11.4 million hectares a year in 1980, according to the UN Food and Agriculture Organization. Over the next 30 years, human population in the tropics is set to double, which will undoubtedly put the forests under even greater pressure. Says Bruce Cabarle, manager of the Latin America Forestry Program at the World Resources Institute, "There really is a catastrophe waiting to happen, both for the forests and the people who live off them."



FRANCIS PUTZ

Destructive embrace. Slashing lianas and other vines before felling a tree spares other trees.

To many conservationists, it's increasingly clear that most of these forests, surrounded by poor and growing populations, can't be preserved simply by fencing them off. "The tropical forests are much too important an economic resource to expect developing countries to simply stop using them," says Richard Harwood, professor of sustainable agriculture at Michigan State University. What's needed are ways of exploiting the forests without clearing them for timber or farming. By and large, these efforts are too late to save the world's temperate forests. There is still time, however, to prevent tropical forests from disappearing. "The situation is serious and demands attention now, but there are concrete things we can do to both protect and utilize to some degree the world's tropical forests," adds Harwood.

In isolated spots around the world, small-scale programs are already showing that low-intensity harvesting, combined with total preservation, can conserve the forest and protect the ecological services it performs, such as erosion control and rainwater retention, while providing food, fiber, and income for those who must live off the forest's bounty. These "sustainable forestry" schemes also include plans to restore forest-like agriculture to previously cleared areas (see sidebar).

These schemes are far from perfect: Advocates admit that even the least obtrusive of these practices—harvesting fruit and nuts or very selective logging—can erode a forest's biodiversity. "We have to accept that using the forest means changing the forest to some degree," says Cabarle. But he adds that with the best of these practices, "the forest retains its ecological functions and its ability to recover over some extended period of time."

One approach is to set aside tracts of forest as extractive reserves, from which area residents can harvest nontimber goods, such as latex, nuts, fibers, and medicines. Conservationists began touting extractive reserves as the solution to deforestation following a 1989 *Nature* paper in which Charles Peters of the New York Botanical Garden's Institute for Economic Botany and his colleagues argued that a hectare of Amazonian rain forest was worth nearly 13 times more as an extractive reserve than as a source of timber.

The researchers had done a systematic inventory of the patch of forest, 30 kilometers southwest of Iquitos, Peru, and found that 26% of the species and 42% of the individual plants yielded products that could be sold in Iquitos. They then determined that the market value of the fruit and latex, minus wages and transportation costs, was $422, while the value of the timber was $1000. But timber, once cut, is gone, while fruit and latex can be harvested yearly. The Peters group assumed that 25% of the fruits were left each year for regeneration; pegging the annual inflation rate at 5%, the researchers determined that the forest was worth $6330 over 20 years, compared to $490—the value of the lumber at the end of that same period.

Numbers such as these are misleading, however, as these researchers and many others were quick to note. For example, not all the fruits are easy to collect—some grow high in the canopy—and harvesting often damages the trees nearly as much as cutting them down. Indeed, recent surveys around Iquitos have found that many of the region's fruit-producing trees are declining in number. And in areas where extractive reserves do exist, the harvesters often receive little of the income from their labors.

Moreover, the slow rate of return on such schemes means that for many countries, logging will remain the most tempting way to

exploit the forests. But even logging could be made far more environment-friendly, according to Francis Putz, professor of botany and forestry at the University of Florida, who has worked with a number of countries to help develop kinder harvesting methods. Most studies of tropical logging damage report that the typical limited logging operation, which extracts the high-value trees equivalent to 10% of the forest area, destroys about 50% of the canopy. Roads and skid trails damage another 10% to 20% of the area. But Putz has found that simple steps, such as cutting canopy lianas before felling a tree, can reduce damage to neighboring trees by 20% to 40%. Putz and others have also learned that carefully preplanning a logging operation—identifying desirable trees and the least-obstructed paths for getting out the logs—can slash damage to the residual area by 50%.

Preplanned logging may also help the forest regrow, says Putz, ensuring future harvests. The key seems to be leaving the surrounding forest undamaged, so that it can reseed the cleared area. And that's the goal of another sustainable logging technique, which seems to be succeeding in the Palcazu valley of eastern Peru: a harvesting method known as strip clearcutting.

The operating premise of strip clearcutting is that more than 60% of the trees in a typical tropical forest take root under gaps in the canopy, created when large trees die. Strip clearcutting creates similar gaps; loggers cut isolated, 30- to 40-meter-long swaths in the forest canopy and take the commercially valuable trees, while area residents use the so-called junk species for making poles, firewood, or charcoal. According to Putz, wind-dispersed seeds from the surrounding uncut trees will then take root in the gap. And although biologists have been unable to survey regeneration in eastern Peru over the past few years because of the Peruvian civil war, earlier studies had shown healthy regrowth in the clearcut areas.

Such logging practices need not reduce profits, say advocates. Loggers are finding that preplanning lowers costs significantly because it reduces the demand for bulldozers to cut roads and heavy tractors to drag logs along unplanned, circuitous routes. In Sarawak, Malaysia, for example, planned cuts increased harvest efficiency by 36%. In Suriname, a logging company saved so much money participating in a pilot project that it offered to pay researchers to design extraction programs for all its logging operations.

For preserving biodiversity, these gentler logging practices aren't ideal. In French Guiana, Jean-Marc Thiollay of France's Laboratoire d'Ecologie found that even 10 years after a highly selective logging operation—loggers had cut no more than three trees per hectare—species richness and abundance in the logged areas was still 25% lower than in unlogged control areas. Still, that's far more biodiversity than would have been preserved if the same area of forest had been cleared.

Whatever the drawbacks of these practices, Putz and his colleagues hope to see them become more widespread; so far, they've taken hold in less than 5% of all forestry operations in the tropics, Putz says. But a rising tide of market sanctions may bring more timber companies around. "Timber companies are afraid that if their timber operations are seen as being destructive to the forest, markets will be closed to their products," says Putz. And consumer organizations in the industrial nations are working hard to make sure that happens through certification programs for wood from timber companies that adopt gentler practices. "With the advent of certification programs," says Putz, "consumers, and even countries, can now choose to boycott lumber not extracted in a sustainable way."

But for sustainable forestry practices to succeed, Harwood believes, pressure from the developed world won't be enough. The Palcazu program has succeeded in large part, he says, because the timber concession there is run by nearby villagers. In fact, most conservationists consider land rights to be critical to forest preservation, a finding supported by a recent report of the National Academy of Science's Committee on Sustainable Agriculture and the Environment in the Humid Tropics. "In the majority of situations where a central government controls the timber rights, forests are overlogged because central governments not only tend to take a short-term view—how can we generate cash and jobs today—but they do little to actually police logging operations....For the most part, communities take a longer-term view of the forest," says Harwood, who chaired the committee. "If the benefits of using the forest continue to bypass the local people, the world's tropical forests have little chance of surviving the next couple of decades."

–Joe Alper

Forest Analogs: A Good Half-Measure?

Most advocates of sustainable forestry hope to get their schemes in place before the forest is destroyed (see main text). But a few ecologists think it's time to start concentrating on what has already been lost. They argue that even if a forest has already been cleared for timber or farmland, some aspects of it can be re-created without depriving local people of sustenance. That's the conclusion of a recent report issued by the National Academy of Science's (NAS) Committee on Sustainable Agriculture and the Environment in the Humid Tropics,* which said, "Many of the rain forests in the humid tropics of Africa, Asia, and South America—cleared for logging, farming, and ranching—could be restored for sustainable uses that boost food production and provide family incomes while minimizing environmental damage."

S. GUESSMAN

Double duty. A cacao plantation in Tabasco state, Mexico, masquerades as a forest.

The report uses the term "restored" advisedly. Once a forest has been destroyed, it can't be restored to pristine condition, at least not while settlers depend on the land. What is feasible, though, is creating what Richard Harwood, professor of sustainable agriculture at Michigan State University, calls forest analogs. "These are reforested areas that perform the ecological functions of the native forests, such as nutrient recycling, water cycling, and erosion control, have commercially useful species that can be harvested in a controlled manner, and have enough biodiversity, including understory, climbing vines, and tall canopy trees, to be self-sustaining," explains Harwood, who chairs the NAS commitee.

The inspiration came from the small cacao farms of Latin America, which meet all the criteria of a forest analog. They have a canopy of cacao trees and a diverse understory of maize, bananas, plantains, and other crops. As in the native forest, the vegetation provides an upper canopy that screens harsh sunlight and torrential rains. Humidity and temperature remain fairly constant at ground level, which contributes to soil regeneration.

It's not a conservationist's dream, but it's better than a ranch, Harwood argues. "Forest analogs are *not* the original forest by any means, and they are not a means of protecting biodiversity, but they can take the pressure off the rain forests that are still intact."

–J.A.

**Sustainable Agriculture and the Environment in the Humid Tropics*, National Academy Press, 1993.