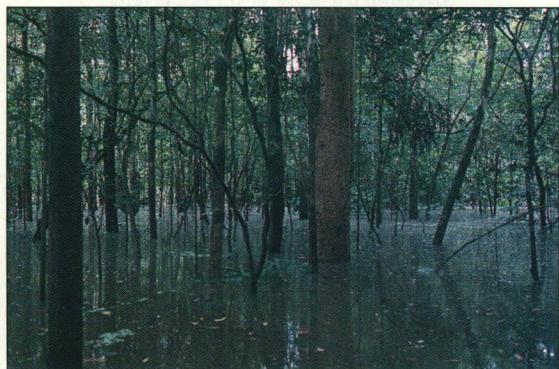


People of the Amazon Fight To Save the Flooded Forest

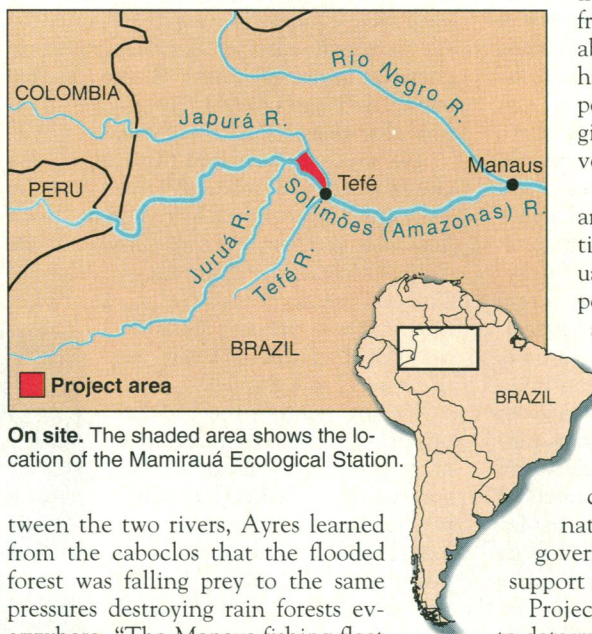
TEFÉ, BRAZIL—In rain forests around the world, from Peru to Guatemala to Indonesia, ecologists and social workers have promoted the sometimes controversial idea that fragile ecosystems can best be preserved not by shutting them off to development totally but by letting indigenous people live in and use them. In a forest reserve about 5 hours west of the steamy Amazonian town of Tefé in northwestern Brazil, those theories on so-called sustainable development are now being taken to an unprecedented level in an effort to save a little-studied ecosystem called the varzea, a species-rich area of rain forest that is partially submerged for much of the year.

In the 11,000-square-kilometer Mamirauá Ecological Station, situated at the junction of the Japurá River with a section of the Upper Amazon known as the Solimões, the local river people, called caboclos, are being turned into de facto park rangers as well as workers in a research study that will be used as the basis of a varzea management plan. While it is still too early to gauge the effectiveness of these indigenous park rangers—the 3-year study kicked off only last year—the research group running the project has lofty goals, including creating a model for saving other endangered rain-forest areas. “Other people are watching us,” says Miriam Marmontel, an aquatic-mammal specialist with the effort, which is known locally as Project Mamirauá. “If it works, some of these techniques will be copied.”



Under water. The varzea may be partially submerged for up to 7 months a year.

Project Mamirauá is the brain child of Marcio Ayres, a Brazilian wildlife biologist with the Wildlife Conservation Society (WCS) and the National Research Council of Brazil. During a 1980s field expedition to study the uakari monkey (*Cacajao calvus calvus*), which only lives in the varzea be-



On site. The shaded area shows the location of the Mamirauá Ecological Station.

tween the two rivers, Ayres learned from the caboclos that the flooded forest was falling prey to the same pressures destroying rain forests everywhere. “The Manaus fishing fleet was emptying the lakes by seine netting,” recalls Peter Henderson, a fish biologist from Oxford University and a colleague of Ayres from the early days of the project. “The caboclos feared the fish would be gone, and Marcio could see the damage done to the canopy by commercial logging.”

Michael Goulding, an author and staff scientist with the Rain Forest Alliance, a New York-based conservation organization, confirms that Ayres had good reason to be concerned. Goulding reports that while nearly 3% of the Amazon basin, approximately 150,000 square kilometers, is comprised of flooded forest, these fragile lands have already been decimated on the lower Amazon, leaving only 25% intact in that area. And the destruction is moving upriver toward the Mamirauá site. What’s more, he asserts, the varzea is a vital contributor to the overall ecology of the Amazon basin because it is a cradle of speciation.

During the 7-month-long wet season, these lowland regions are inundated to depths of up to 10 meters or more—enough to completely cover many low-growing plants and to partially submerge taller trees and shrubs. Both plants and animals have had to make special adaptations to live in this watery environment. For example, the primitive boto dolphin may have survived in the varzea because its flex-

ible neck helps it to navigate in the flooded forest and avoid the tangle of roots and limbs in the area, while its more advanced cousins lack this ability.

The varzea also provides an efficient means for dispersing the genetic material that evolves there, as every time it floods it’s invaded by hundreds of seed- and fruit-eating fish species. “It is reasonable to argue that the flooded forests have been more significant as gene pools for terra firma [the drier regions of the rain forest] than vice versa,” Goulding maintains.

With so much at stake, Ayres, armed with family political connections and the very photogenic uakari, which he used as a kind of poster child, mounted a campaign to save the Mamirauá region. In 1990, he convinced the Brazilian federal government to set aside the portion of the varzea bordered by the Solimões and Japurá rivers as an ecological station and collected \$4.3 million from international sources like the WCS and the government of the United Kingdom to support and study the preserve.

Project Mamirauá’s immediate goals are to determine how the varzea actually works and inventory what lives there. “Little is known about the flooded forests. Not even the maximum and minimum water levels are known,” Ayres explained in his grant applications to the funding agencies. Given this largely blank slate, Goulding says, “Mamirauá is going to generate a lot of important biological information.” Indeed, Henderson and Will Crampton, an Oxford doctoral candidate, have already found fish species they think have never been described before.

Some of the goals of the project are not science-related, however, and have generated controversy. When the preserve was declared, some ecologists wanted the caboclos moved out in accordance with a Brazilian law that forbids settlements in parks and preserves. But instead, the project has been working to turn these peasants into game wardens and permanent caretakers, a tactic that has not always met with approval from rain-forest researchers because some feel locals make poor land managers. Goulding, for one, thinks economic pressures might thwart the best intentions of the local population and force them to log or overfish.

But given the scant resources the Brazilian government musters to enforce park laws (an average of one ranger per 366,000 square kilometers of protected area), Ayres argued that the caboclos, with their self-interest in maintaining the ecosystem that has supported them for so long, would make ideal caretakers. Besides, with only one family per 950 hectares, violations by the caboclos

would have only a minor impact compared with the more severe depredations of commercial fishers and loggers.

So far, the gamble seems to be paying off. Most caboclos seem pleased by their new status, even though it means that certain forest zones are now off-limits to their use. "We are in a privileged situation," says one village leader. "We are lucky to be able to live here, to stay now that this is a preserve." One reason for their contentment may be that they have been given valuable incentives to compensate them for the restrictions they now face.

Communities have been given aid subsidies, for example, and almost all manual labor used by the project comes from the vil-

lages in the preserve. In particular, the project has been careful to select village leaders and sons of leaders as employees. And income-generating experiments, the traditional way sustainable development works, are being tried. These include pilot projects to grow camu-camu and other fruit-bearing trees with commercial potential, and a census of the discus fish is being taken to determine if it can be culled for the aquarium trade.

And Marmontel, who spends much of her time in the preserve and works closely with the caboclos, believes there are signs that the plan to use them as guardians against illegal fishing and logging is working. She has noted marked declines in both activities despite threats and some confrontations from armed

gunmen on fishing boats and in logging camps. When the caboclos find an offender, they usually try friendly persuasion, but if the loggers or fishers refuse to leave, the caboclos report them to the project, which in turn calls in a federal ranger.

Whether Project Mamirauá lives up to its early promise and becomes a model for other rain forests remains a long shot against the seemingly inexorable march of rain-forest depletion. But for now it appears to be holding back that march toward this one small but important chunk of the Amazon basin.

—Brian Alexander

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COSMOLOGY

On the Track of Dark Matter in Mica

Researchers have recently been employing some heavy-duty equipment to search for "dark matter"—the mysterious invisible material that some cosmologists believe could account for up to 99.9% of the mass of the universe. With high-speed computers and dedicated telescopes, astronomers are monitoring millions of stars daily, looking for subtle brightness fluctuations caused by interceding clumps of dark matter; others are deploying sensitive detectors underground, patiently waiting to pick up the signal of a rare collision between a single dark matter particle and normal matter. Then there's Daniel Snowden-Ifft. He is looking for dark matter by cracking open old rocks.

Snowden-Ifft, a physicist at the University of California, Berkeley, and his colleagues are taking billion-year-old mica—a mineral composed largely of hydrogen, silicon, oxygen, aluminum, and potassium—and examining it for microscopic trails of destruction. These tracks would be caused by certain theorized dark-matter particles that interact infrequently with ordinary matter. Like photographic film exposed for a billion years, however, ancient mica should have been around long enough to record many encounters if these dark-matter particles exist.

In the end, studying mica may not actually tell us what dark matter is, but it could rule out a number of popular candidates. And this low-cost strategy to narrow the search impresses other seekers of dark matter. "It's a very clever technique. It certainly captures the imagination," says University of Chicago astrophysicist Michael Turner. "I'm impressed by the quality of the work....It's a very elegant method," agrees Bernard Sadoulet, who directs UC's Center for Particle Astrophysics and leads a team working with an underground particle detector made of cooled germanium crystals.

Ancient mica was first enlisted at Berke-

ley as a particle detector more than a decade ago. Physicist P. Buford Price and his colleagues scanned mica samples gathered from museums with an optical microscope for signs of encounters with proposed particles of magnetism called monopoles. In 1990, Snowden-Ifft, then a graduate student in Price's lab, read about a family of dark-matter candidates called weakly interacting massive particles, or WIMPs. He realized they shared some characteristics with monopoles and proposed searching for them in mica.

Particles such as WIMPs—and monopoles—would normally fly through matter without pause, say theorists. But from time to time, a WIMP should directly collide with an atom's nucleus. If that happened in mica's well-ordered crystal lattice, the recoiling nucleus would knock neighboring atoms out of position, producing a detectable wake of damage.

Over its billion-year lifetime, if WIMPs do indeed exist, even a tiny chunk of mica would register many such recoils.

Snowden-Ifft's strategy is to take mica, cleave it, and then etch the new face with hydrofluoric acid for a few hours. The acid eats away faster at sites where mica's lattice has been disrupted by a moving particle, producing microscopic pits. The recoil track from a WIMP collision should produce pits too small for an optical microscope to see, so the team works with an atomic force microscope (AFM), a device that uses a delicate cantilever-borne stylus, like a needle on a record player, to trace the surface of an object with atomic resolution. For a WIMP of a particular mass and size, physicists can calculate the number of tracks they should dis-

cover in mica of known age. If they don't see that many tracks, they can rule out the existence of that WIMP and limit cosmologists to thinking about candidate particles that must be smaller or lighter.

The Berkeley group has already carried out a trial dark-matter search on one piece of mica, scanning one thousandth of a square centimeter of the mineral. In that small area, they found no possible WIMP tracks, allowing them to dismiss very large or massive WIMPs.

With only this modest initial effort, claims Snowden-Ifft, "we're setting limits comparable to the best detectors to date."

The Berkeley lab is now buying its own AFM and plans to significantly scale up their dark-matter search by looking at more and more mica. "Basically, we're going to scan until we start to see stuff," says Snowden-Ifft. The search should in the end be limited by noise—a background of recoil tracks, indistinguishable from WIMP re-

coils, produced by cosmic rays or the neutrons of radioactive atoms normally found in and around the mica. Although some researchers feel these background events will prevent the mica effort from progressing much beyond its current limits, Snowden-Ifft believes the technique could eventually set mass and size limits that rule out some popular dark-matter candidates such as WIMPs called neutralinos. The key, he says, is to reduce background noise by finding mica samples less contaminated by cosmic rays and neutrons. If Snowden-Ifft and his colleagues are successful in their paradoxical search to find nothing in mica, "it could cause one to pause and say we should reconsider our [other WIMP] experiments," notes Turner.

—John Travis



Mining mica. Pits like this may unveil dark matter.

DANIEL SNOWDEN-IFFT/UC BERKELEY