Amazon forests caught in fiery feedback

One little fire inching through a tropical forest may not kill much. Yet it triggers a vicious cycle—fires preparing the way for bigger fires—that could ultimately turn Amazon jungles into savannas, according to new research.

During a typical 16-day dry spell, only some 5 percent of an intact rain forest dries out enough to catch fire, says Mark A. Cochrane of the Woods Hole (Mass.) Research Center. But even a small fire can sufficiently tatter the shade canopy —and leave behind enough extra debris for fuel—to render some 50 percent of that forest vulnerable to a second, more destructive blaze during a subsequent dry spell. As fires recur, virtually all the forest becomes susceptible, report Cochrane and Mark D. Schulze of Pennsylvania State University in State College.

Brazil's Tailândia region in Pará has already slipped into this fiery feedback loop, observe Cochrane and Schulze in the October CONSERVATION BIOLOGY.

A decade ago, Tailândia was the new Amazonian frontier. Settlers moved in, and accidental fires became common. Now, forests there that have previously caught fire reburn about every 3 years, too quickly to allow regeneration. Historically, the time between forest fires was at least 400 years.

"Fire is burning everything and everyone," Cochrane says. On a data-gathering trip last December, he found that fire had destroyed even the Brazilian forest service's sustainable management plot.

The first fire that attacks an intact Amazon forest looks "unimpressive," admits Cochrane. Most of the time, the flames spread as a thin ribbon barely ankle-high, creeping perhaps 100 meters a day. These fires take the night off, winking out around 5 p.m. and reigniting from smoldering sparks when the next day heats up around 10 a.m. They kill thin-skinned young trees but typically leave 90 percent of the forest's biomass alive.

A year after such a fire has worked through a forest, however, the tree canopy provides only 60 percent shade instead of its former 85 to 95 percent, the researchers report. Trees no longer create as much moist cover as they used to, and the next fire starts more easily, this time burning some 40 percent of the biomass. Unlike the first fire, the second one kills big trees as often as little ones.

Longtime tropical fire watcher Christopher Uhl, also from Penn State, comments in the same journal issue that "fire adds a whole new dimension to tropical disturbance ecology." Long gone are the days when researchers observed that Amazon jungles didn't burn. Uhl once sheltered part of the forest floor from rain for more than a month but couldn't get a blaze going. Now Uhl sees fire as a huge force for change in rain forests. "Even for those species that survive, these grand fires might be among the largest biological selection events in modern history."

The feedback effect does not surprise Norman L. Christensen, dean of the Nicholas School of the Environment at Duke University in Durham, N.C. "The pattern is similar to what we see in some of the coastal forests in the Pacific Northwest," where ecosystems have not evolved to cope with frequent blazes.

In other temperate forests, however, small fires have the opposite effect and reduce the chance of future blazes, notes James K. Agee of the University of Washington in Seattle. Little fires lap up dead leaves and branches, preventing fuel from building up. Adaptations like thicker bark protect trees. Forest managers now set these so-called prescribed burns as preemptive housekeeping blazes.

"My take-home message is that we wouldn't want to take those temperate [forest] ideas and try to apply them too strongly to the tropics," Agee says. "Ecology is really a science of place."—*S. Milius*

Cochrane

Even a sleepy, ankle-high blaze can trigger a vicious cycle of fires in Amazon forests.

Probing the heart of extragalactic jets

Astronomers have come a little closer to finding the origin of the twin jets that shoot out from the brightest objects in the cosmos. Some 10 percent of quasars and active galaxies emit such jets, which extend in opposite directions up to thousands of light-years.

By studying the radio emissions from the jets squirted out by the distant quasar 3C279, researchers have gathered the first compelling evidence that the jets consist mainly of electrons and their antiparticles, positrons. This composition hints at the processes taking place deep within the hearts of active galaxies, where the jets are produced.

Any bright galactic core not powered by starlight is known as an active galactic nucleus. The most luminous of these are called quasars, and they are thought to be fueled by massive black holes. The new observations point to interactions between subatomic particles just outside a black hole as the source of the jets.

John F.C. Wardle and his colleagues at Brandeis University in Waltham, Mass., used the Very Long Baseline Array, a network of 10 radio telescopes, to examine the radio waves emitted by the jets in 3C279. They measured the polarization, the direction in which the electric field of the radio waves oscillates.

In the Oct. 1 NATURE, Wardle's team reports finding circularly polarized radiation from the jets, meaning that the angle at which the electric field oscillates is not fixed but rotates around the wave's direction of travel. Earlier observations indicated that most of the radio emission comes from high-speed electrons accelerated by a magnetic field. Scientists had also determined that there must be roughly equal numbers of positive and negative charges in the jets, but they didn't know whether the positive charges were protons or positrons.

The pattern of polarization found by Wardle's team indicates that the electrons' positively charged companions are mostly positrons. The team has found similar results in jets from three other active galactic nuclei.

There are two ways to make beams of positrons and electrons, says Thomas W. Jones of the University of Minnesota in Minneapolis. In one scenario, material falling toward the black hole generates high-energy photons, which collide to produce pairs of electrons and positrons. These particles in turn radiate more photons, which create more electron-positron pairs. One drawback to this story line, says Jones, is that if the radiation generated by infalling material is too intense, it may act as a brake on the electrons and positrons, preventing them from attaining the high speeds observed in the jets.

A more likely possibility, he notes, is that energetic protons, too massive to be slowed by radiation, collide with either each other or photons. These reactions generate subatomic particles called pions, which can decay into electrons and positrons. The reaction also generates a small number of protons, consistent with the observation that most but not all the positively charged particles are positrons. —*R. Cowen*