Monitoring the Fate of the Forests from Space

Remote sensing is a powerful tool for assessing rates of deforestation and answering questions about global warming and biodiversity; so why isn't anyone doing it?

WHEN ALBERTO SETZER and his colleagues at the Brazilian Space Institute released satellite images of the Amazon Basin last year, the pictures were anything but pretty. The satellites recorded thousands of fires raging across millions of hectares of tropical forest, with smoke plumes that rose like cumulus clouds from the smoldering ashes below.

Setzer's satellite images threw the conservation community into a panic, for Setzer reported rates of deforestation far greater than what was generally believed to be occurring. Now a group of ecologists and experts in remote sensing are calling for a worldwide, "wall-to-wall," systematic assessment of the rates of deforestation in the tropical world, the region where disruption is most rapid and the effects most dramatic. Moreover, the scientists say such an assessment could be done for about $5 million a year, an amount that is almost invisible in the budgets of most federal agencies.

"Many people are talking about the importance of quantifying deforestation, but nobody is actually doing the work. It's pathetic," says Compton Tucker of NASA's Goddard Space Flight Center in Maryland.

The need for such data is acute, says Tucker, who stresses that the satellites are already in orbit, the technology already exists, and the researchers are ready to go. Says Tucker: "Let's face it, in another 10 years, it won't be worth doing."

It is the accepted wisdom that the tropical forests are rapidly disappearing. In some areas, such as the state of Rondônia in Brazil, the jungle is being slashed and burned by colonists who leave the overcrowded cities and follow the newly paved roads into Brazil's vast and largely unexploited interior. In other parts of the world, notably in West Africa, the forests are not being felled but are slowly degrading. No one knows with any certainty the rate, or even the extent, of deforestation.

Based on data almost a decade old, current estimates of the amount of primary and secondary forests converted to other uses vary wildly, ranging from 5 million hectares a year to 42 million. In Brazil alone, Setzer reports that as many as 8 million hectares of forest were burned in 1987, a figure that exceeds some estimates for *worldwide* deforestation.

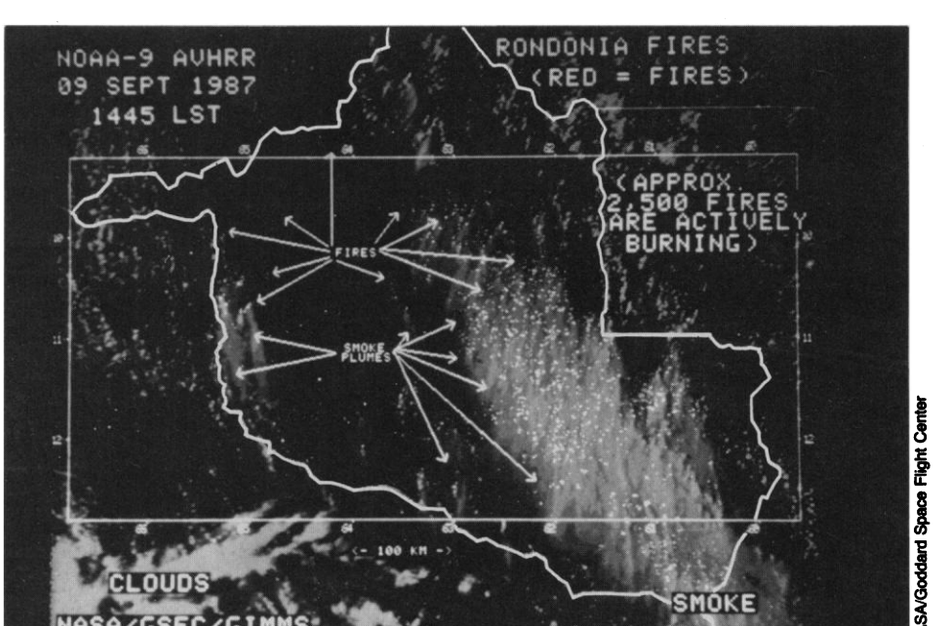
Also unknown is how much carbon is being released into the atmosphere each year by the clearing, burning, and degradation of forests. For those interested in understanding, and perhaps even mitigating, the global warming associated with the greenhouse effect, this figure could prove extremely important.

Researchers who study the sources and sinks of carbon dioxide, the principal gas responsible for the greenhouse effect, are relatively confident that about 5.5 billion tons of carbon enter the atmosphere each year by the burning of fossil fuels. However, the scientists who create the models upon which the predictions of global warming are based are far less certain about the amount of carbon that enters the atmosphere as a result of forest clearing and changes in land use, says Robert Dickinson of the National Center for Atmospheric Research in Boulder, Colorado. Current figures range from 0.4 billion to 2.5 billion tons of carbon a year, and even these may be out of date.

Deforestation has been tracked with satellites in many parts of the tropics. Indeed, Tucker and colleagues at NASA, and other groups in the United States and elsewhere, have surveyed some regions in detail. But the monitoring is sporadic and uncoordinated. Some countries assess their resources often; some take only the occasional snapshot. "Pieces are being done, little pieces here and there, but that's not enough," says Richard Houghton of the Woods Hole Research Center in Massachusetts.

In the United States, the job of monitoring deforestation has fallen between the cracks. Agency officials plead tight budgets or say that monitoring forests falls outside of their mandate. The Environmental Protection Agency, which is under the gun to come up with policies to address global warming, is not doing it. Nor is the beleaguered National Oceanic and Atmospheric Administration, which owns the weather satellites and the off-again, on-again Landsat orbiters (see box on p. 1429). At NASA, monitoring tropical deforestation is "a low priority," says Robert Murphy, head of land processes at the Earth Science Program at NASA. NASA spends about $3 million a year on its Terrestrial Ecosystem Program, which includes about $100,000 for developing the tools to assess tropical deforestation.

On the international scene, the Food and Agriculture Organization is joining forces with other agencies such as the United Nations Environment Program to assess the state of the world's forests in 1990. The idea, according to K. D. Singh of the FAO in Rome, is to gather up all the reliable



NASA/Goddard Space Flight Center

The view from space. *This slide was generated from data collected by NOAA-9 weather satellite as it passed over the state of Rôndonia in Brazil. Note the fires and large smoke plumes.*

information that already exists and to use the data to tabulate rates of deforestation over a period of time. Singh plans to fill in the gaps in global coverage by ordering more data from satellites, but he concedes that this is an expensive undertaking. Singh says the project should be complete in the early 1990s and will cost a total of about $3 million.

Tucker and his colleagues say that the United States could begin monitoring deforestation immediately and that the entire job would cost no more than $5 million a year. Their plan calls for using a pair of NOAA weather satellites to gather relatively crude data over very large areas, and then to use the more expensive but more detailed images of the Landsat satellites to focus on certain hot spots. Random ground checks could corroborate the data and provide information about the forces driving deforestation, providing countries in the tropics can be encouraged to participate.

Though the NOAA weather satellites were designed with meteorologists in mind, the remote sensing community discovered that the sensors aboard the polar-orbiting satellites could be used to distinguish forest from nonforest. On one channel in the mid-infrared region, forests appear cooler and clearings warmer. This was very fortuitous. The NOAA satellites pass over the entire globe every single day. They can cover a huge swath of a continent on a single orbit. Such frequent coverage over such a large land area is particularly attractive if one is interested in monitoring fires or deforestation in the tropical world, which is often shrouded in clouds for weeks at a time. Frequent coverage gives one a better chance of at least getting one cloud-free image every few weeks.

The information from the weather satellites could be backed by the Landsat images, which provide highly detailed images with a resolution of 30 meters, as opposed to the NOAA weather satellites with a resolution of more than 1 kilometer. The problem with Landsat is that for global monitoring it almost produces too much data. At $3600 a "scene," it is also expensive. One would have to purchase more than 200 Landsat scenes just to survey the Amazon Basin. Tucker says the best approach is to combine NOAA and Landsat images.

"It's fine to talk about going to Mars with the Russians, but we're becoming more and more aware that we've got problems right here on Earth that we should be addressing," says Barrett Rock of the University of New Hampshire. "We ought to be using our space program to look down rather than up."

■ WILLIAM BOOTH

Landsat Wins a Reprieve

Vice President Dan Quayle, chairman of the National Space Council, stepped in last week to rescue the Landsat earth imaging satellites from an early demise.

Until Quayle's intervention on 6 March, the government had planned to turn off both Landsats 4 and 5 this month and also shut down archival data services (*Science* 24 February, p. 999).

Landsat's patron, the National Oceanic and Atmospheric Administration (NOAA), received no funding in the 1989 budget to run the system after 31 March and did not want to sacrifice other programs in its account just to keep these popular satellites going. Although many congressmen like Landsat, they failed to provide a full year's funding because the satellites had already outlived their expected lifetime. But the company that manages the system says it can keep them working until 1991.

The Vice President stepped in last week, promising to keep the Landsats alive at least for several months while his staff undertakes a review of the situation. It will be the fourth such review in less than a year. At Congress' behest, NOAA has spent $2 million for other studies on the prospects for "commercializing" Landsat. The studies were finished in August but have been kept under wraps by the Office of Management and Budget, which may not like their conclusion that Landsat is a healthy but immature enterprise that will require federal subsidies for the rest of this century.

As Landsat's savior, Quayle may find he has taken on a bigger challenge than he expected. The rescue announcement has not been followed as yet by any funding details, and NOAA officials still do not know where the money will come from to keep the system running after the end of the month. They have agreed not to pull the plug. But there are reports that the Vice President has secured pledges from only two agencies—the Department of Defense and the National Aeronautics and Space Administration—each of which agreed to contribute $2 million toward this year's $9.4 million funding gap.

The rescue announcement came just a day before an emergency hearing on the subject in Congress, called by Representative James Scheuer (D–NY), chairman of the House science subcommittee on natural resources. Scheuer and several other senior members—including Representatives Robert Roe (D–NJ) and George Brown (D–CA)—politely flogged the NOAA spokesman for the "damn nonsense," as Roe said, that pervades U.S. space policy. Brown collected the signatures of 100 congressmen on a letter appealing to the Vice President to defend "one of the greatest triumphs of the nation's civilian space effort." Scheuer said it was a "disastrous, aberrational decision" to throw away $1.5 billion worth of Landsat equipment to save $9 million in operating costs.

Thomas Pyke, Jr., assistant administrator of NOAA for satellite and information services, promised to keep Landsat going but conceded that the "details of the interim funding plan are not available." Meanwhile, NOAA is seeking emergency financial help from the Earth Observation Satellite Company (EOSAT), the firm that won an exclusive right to commercialize the Landsat data and has profited from it since 1984. EOSAT's president, Charles Williams, responded that before investing any further in the system, he wanted an assurance from the government that it would reimburse the company.

Scheuer gibed: "The government and you are acting like a bunch of rug traders when there are real national interests at stake." Representative Dave McCurdy (D–OK) said he thought federal agencies were "playing a pretty expensive game of chicken" over Landsat, and that a decision to shut the system down for 2 years would be "devastating" to the plan to convert it into a commercial enterprise, which was the proclaimed reason for moving it out of NASA in the first place.

As Landsat sponsors continue the debate over who will pay the bills, competitors are moving aggressively into the earth surveillance business. Ray Cline, a former intelligence official now at Georgetown University, testified at the hearing that there may be as many as 24 nations or multinational organizations operating satellites in space by the year 2000, and even the Soviet Union is now peddling satellite photos to the public. "If we turn off Landsats 4 and 5," he concluded, "we could be setting ourselves up for a major strategic disaster." ■ ELIOT MARSHALL