major reduction (around 20%) in peak ozone levels. Recent studies have been more conservative, he says, and, as a result, the predicted benefits "have been coming down." He thinks they may come down further.

The most often quoted findings today are those of Armistead Russell at the Carnegie Mellon University, showing that a switch to M85 cars in Los Angeles beginning in 1990 could reduce peak ozone levels in a 3-day smog attack in year 2000 by 8%. A switch to M100 cars could reduce the peak levels 16%. Benefits like these are significant and worth pursuing, if they remain credible, says Robert Hahn, a former White House economist who worked on the President's plan.

Faced with pressure from the White House, Congress, and, importantly, from the state of California (which has already agreed to buy several thousand M85 cars), the petroleum industry may decide that it is best not to fight but to join the clean fuels brigade. This strategy has worked well for the ARCO petroleum company of Los Angeles, which introduced a reformulated "gasoline" last summer called EC-1. Although ARCO won favorable publicity for its eco-consciousness, executives at other companies point out that it was acting under a state mandate to clean up a leaded regular gasoline it was selling to owners of old cars. EC-1 was designed for a limited market, and the chemical engineering involved does not have broad application, competitors say.

Nevertheless, leaders in the petroleum industry are talking about making reformulated gasolines to compete with methanol. No specifics have been revealed as yet, and many observers are skeptical that refiners can change traditional gasoline without running up the cost.

In all likelihood, the clean gasoline campaign will not yield a product any time soon but will give birth instead to a major research program. Says Eugene Spitler, general manager of product engineering at Chevron USA, "We have only rather preliminary data indicating what might be done." It might be possible to lower the aromatic content, if aromatics are what contribute most to ozone formation. But it isn't clear that they are at fault. Perhaps fuel injection systems can be improved, he says. There is the possibility of reducing the butane to lower volatility, but that would lead to octane loss that would not be easy to remedy. Spitler concludes: "Our position is that all of this ought to be looked at. There needs to be more research."

This is a message Congress will hear more than once in the next few weeks as it weighs the pros and cons of methanol as an auto fuel. ■ ELIOT MARSHALL

A Catbird's Seat on Amazon Destruction

Brazil's space agency is playing an expanded role in monitoring the nation's environment; four new satellites planned

São Jose dos Campos, Brazil

"THE EFFECTS ARE MUCH WORSE than those from saturation bombing. You end up with massive smoke clouds spread over millions of square kilometers. In some places, visibility is so bad you have to wait days for things to clear up if you want to travel by plane or car. There are literally thousands of fires, and I'm just talking about the larger ones, at least 50 meters across."

The speaker is not an impassioned environmentalist visiting from the United States, but a cool and respected Brazilian space scientist, Alberto Setzer, head of Amazon studies for the National Space Research Institute (INPE). Though all too many Brazilians still seem cavalierly indifferent to the destruction of the rain forest—indeed actually favor it—a growing number of Brazil's scientists are becoming increasingly concerned by it. Nowhere is the sense of alarm more pronounced than at INPE, popularly known as the Brazilian NASA.

In fact, INPE's scientists are doing more than expressing alarm. The institute has recently been given expanded powers to monitor the destruction and assist in efforts to curb illegal burning. And its technical capabilities to keep track of Brazil's environment will soon be dramatically expanded with the launch in the 1990s of four remote sensing satellites of its very own.

Based in a suburb of São Paulo, INPE is headquartered in a palm-fringed compound of starkly modern low-slung buildings that wouldn't look out of place at the Kennedy or Johnson space center. Since 1973 INPE has been receiving images from the American space agency's Landsat satellites, whose infrared sensors can provide fresh views of Brazil's vast land area—as big as the continental United States—every 16 days.

The satellites also offer a unique catbird's

Frederic Golden

Amazonian mosaic. *Remote sensing head Robert Pereira da Cunha figured that 5% of the Amazon region has been deforested. The World Bank had touched off a bitter dispute with an estimate that 12% of the rain forest had been lost by fire and flooding since 1978.*

seat on the annual burning, which is now again at its height in the Amazon region, as farmers and ranchers take advantage of the dry austral winter months of August and September to torch felled brush and trees to create more pasture and farmland. Under Brazil's succession of military governments, which favored opening up the rain forest for development and strategic reasons, INPE's ability to use remote sensing to monitor burning was largely ignored. But that has now changed under Brazil's new civilian government.

Much more sensitive than its military predecessors to the country's ecological well-being, President Jose Sarney's government has moved on several fronts. It has adopted a new constitution with a strong environmental protection clause; created an environmental protection agency, IBAMA; taken away some of the economic incentives for forest clearing; placed new restrictions on burning; and begun a national environmental consciousness-raising effort, called Nossa Natureza (Our Nature), featuring such things as television spots, posters, and pamphlets on the perils of slash-and-burn agriculture.

To be sure, many of these tough-sounding measures remain largely unenforced. But the mini-wave of environmentalism has been taken seriously at INPE. Since 1985 its scientists have been collaborating closely with NASA researchers on an important climatic investigation called Project ABLE (for Atmospheric Boundary Layer Experiment). This effort seeks to determine the rates at which key atmospheric gases (for example, carbon dioxide, methane, ozone, and nitrogen oxides) are transferred from the earth's surface into the upper reaches of the troposphere, where they become part of global circulation patterns and can affect weather and climate. Monitoring the injection of gases into the troposphere by forest burning is an important part of INPE's contribution to the project.

The tropics are especially important to this mixing process because, as Gerald L. Gregory, an atmospheric scientist at NASA's Langley Research Center in Hampton, Virginia, explains, "it's where the action is—you have a large surface area, high temperatures and moisture, and lots of energy to drive the mixing."

Samples of the gases are collected simultaneously by a highly instrumented NASA plane circling over an area at various altitudes and by scientists on the ground. So far, the INPE and NASA scientists have undertaken two samplings in the Amazon region, both at a site near Manaus—one during the 1985 dry season and the other during the 1987 wet season. INPE scientists also accompanied NASA's ABLE team when a similar run was made over the Arctic last year. Says Gregory, "The Brazilians were very cooperative. They're extremely interested in knowing the severity of any damage to the environment."

But INPE's dealings with NASA haven't always gone so smoothly. When the Reagan Administration began wavering in its commitment to the Landsat program in the mid-1980s, relations between NASA and INPE "degraded somewhat," says Marcio Barbosa, INPE's director general. To ensure themselves a steady flow of pictures from space, the Brazilians signed up to receive images from France's rival SPOT satellite system.

They also decided to build their own remote sensing satellites, along with the rockets to launch them. The first of four scheduled Brazilian satellites is expected to be lofted in 1991 or 1992. Traveling in a near-polar orbit, it will be able to "read" environmental data from 200 different sites around the country and download them to a central collection station. Additional earth-resources satellites will be launched later in the decade by Chinese Long March boosters under a joint program with Beijing. Brazil is not building remote sensing satellites just for the luxury of having its own system, though. It sees the development of an independent space capability as an important way to stimulate innovation across a range of key technologies.

A yet more serious quarrel with the United States broke out earlier this year after the World Bank published figures on the extent of deforestation in the rain forest. The bank estimated that as much as 12% of the rain forest—598,921 square kilometers, an area as large as Morocco—had been destroyed by fire and flooding since 1978. The figures incensed President Jose Sarney, who felt they were exaggerated. He promptly ordered INPE to undertake its own study based on satellite data.

"What's really important is not whether deforestation is 5 or 8 or 12%, but what can be done to halt it."

—Dennis I. Mahar

The job was turned over to INPE's director of remote sensing, Robert Pereira da Cunha, who quickly assembled a team of 34 forestry experts to analyze the most recent (1988) set of Amazon images from Landsat's thermal mapper. The group spent a month, including weekends, painstakingly going over 101 images, each covering an area of 35,000 square kilometers. And it came to a much different conclusion from the World Bank's. Da Cunha figured total deforestation at 251,429 square kilometers, or 5.12% of what Brazilian authorities call the legal Amazon, a huge multi-state area of rain forest, savanna, and wetland about as big as all of the United States west of the Mississippi.

The Brazilians attribute the gross discrepancy in the two estimates to a bad assumption by the World Bank, which based its conclusion on projections of past burning rates. It figured these would increase exponentially rather than linearly, says da Cunha. Indeed, the rate did jump by a spectacular 40% in 1987 when Brazilians cleared 85,000 hectares, an area larger than Holland, in anticipation of the constitutional changes that were being written to protect the environment. At that rate, the rain forest would be gone in a century. But since then, says da Cunha, the burning rate has dropped markedly.

For his part, Dennis I. Mahar, the author of the World Bank's report, doesn't dispute INPE's absolute number, only its percentage, which he calls "misleading" because it is based on the total land area of Amazonia, including savanna and wetlands, rather than just rain forest.

Mahar, an economist who has lived in Brazil and worked for the government, says he understands the Brazilians' anger. "The World Bank figures got a lot of press, and Brazil felt especially picked on," says Mahar, adding that he hopes the storm will blow over. "What's really important is not whether deforestation is 5 or 8 or 12%, but what can be done to halt it," he says.

On this point, the Brazilian scientists seem to agree. INPE is now regularly monitoring fires with the help of both Landsat and NOAA satellite data and passes on the coordinates of larger blazes to IBAMA, which sends out rangers to check if the burning is legal. Enforcement still remains a problem because local authorities are more likely to take the side of ranchers and farmers eager to continue the fires. And some of INPE's low-flying observation planes have actually been fired upon. But INPE appears determined to continue its fire-monitoring efforts and has even invited NASA remote sensing experts to its headquarters later this year for advice on how to get the most accurate information out of the satellite data. ■ **FREDERIC GOLDEN**

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