By pulling carbon dioxide out of Earth's atmosphere, the Amazon could give humanity the breathing room needed to mitigate climate change—if the numbers add up.

PHOTO: © FILIPE FRAZAO/ALAMY STOCK PHOTO

GLOBAL CHANGE

Amazon rainforest to get a growth check

Ambitious experiment will test whether rising CO_2 will boost the tropical carbon sink

By **Daniel Grossman**

David Lapola was lost. For half an hour on a steamy March day, he and his companions had tramped through virgin Amazon jungle kilometers from any paved road. They were looking for a particular site, one of eight that Lapola had marked with orange surveyor's tape about a year before. Lapola dodged a 2-meter-long tree snake. Plot 8 was nowhere in sight. Then one of the others pointed. "Just beyond the big tree," he said. "What big tree?" Lapola asked. Scores of trees loomed nearby, many with trunks that soared 30 meters into the humid air.

It was an apt reminder of the challenges facing what Richard Betts, the head of climate research at the United Kingdom's Met Office Hadley Center in Exeter, calls "one of the most exciting experiments on the planet." Lapola, a biology professor at São Paulo State University in Brazil, is a lead scientist in a project that could help answer whether the mighty photosynthetic engine of the Amazon rainforest will consume enough atmospheric carbon dioxide (CO_2) to slow global warming. The day after the forest trek, in an air-conditioned conference room 50 kilometers to the southeast in the Amazon Basin's largest city, Manaus, Brazil, Lapola and his colleagues from Brazil, the United States, and Europe discussed the daunting logistics of the experiment, known as AmazonFACE, which they hope to launch next year.

FACE (Free-Air Carbon dioxide Enrichment) experiments have been conducted at dozens of sites in more than a dozen countries. The idea is simple: Researchers spray pure CO_2 continuously into an instrumented plot, raising ambient concentrations to match levels expected as humans continue to spew the gas, and study what happens to the plants. That's a key question because through photosynthesis, land plants currently take up about a quarter of the CO_2 humans add to the atmosphere each year, sequestering it as wood and as soil carbon. This natural uptake slows the buildup of CO_2 in the air, moderating global warming. "*Nature* has done us a fantastic favor," says Scott Denning, an atmospheric scientist at Colorado State University, Fort Collins.

But many of the hypothesized carbon sinks could be winding down. Although abandoned pastures and fields in the Northern Hemisphere absorb carbon as they grow back into woodlands, for example, the uptake slows as they mature. But many scientists suspect that higher levels of CO_2 "fertilize" the rainforest, speeding its growth and creating a major carbon sink that could keep sopping up the greenhouse gas indefinitely, even as climate change makes forests such as the Amazon inhospitably warmer and drier. "It would be wonderful for humanity," Denning says.

That's the hope that AmazonFACE aims to test. For 12 years, Lapola and his collaborators plan to study 30-meter disks of forest, the elusive plot 8 among them, in the Cuieiras Biological Reserve near Manaus. Sixteen perforated tubes dangling from 35-meter towers will fumigate the plots with computer-controlled doses of CO_2, raising the concentration of the gas to 600 parts per million, or about twice the preindustrial level, which the world could reach by 2050. To conserve CO_2, the tubes will spray only in daylight, when photosynthesis takes place.

The experiment will start small, with a 2-year study of one treatment plot and one control, and then expand to four treatment plots and four controls, Lapola says. Researchers will meticulously measure the daily growth of tree trunks, the areas of leaves, and the buildup of debris on the forest floor. Instruments will collect meteorological data and monitor the composition of the air and respiration in the soil; special underground cameras will observe root growth.

Previous FACE studies have tested the responses of grasslands, deserts, temperate forests, and bogs. But nobody has undertaken one in a tropical forest, where the high canopies and remoteness pose daunting challenges. "Nothing's as hard as getting high CO_2 in a rainforest," says Patrick Meir of Australian National University in Canberra, one of Lapola's collaborators.

The discussions in Manaus underscored just how many nagging details remain to be worked out. Hardware for controlling and dispersing the CO_2 must be designed and manufactured. Researchers must decide the best way to ship CO_2 to the site. Should they buy it from Carboman, the Manaus supplier that puts the fizz in the hot city's Coca-Cola, or tap a cheaper source on the other side of the country and ship it up the Amazon River? Should they upgrade the treacherous 34-kilometer dirt road to the site, or find a special vehicle able to haul 15 tons of gas on the difficult last leg of the journey? Lapola had recently test-driven a truck that might work: a modified mobile missile launcher made in the Czech Republic.

Construction at the site should get underway by the middle of next year, Lapola says. So far, he has raised about $4 million in grants from the Inter-American Development Bank and two Brazilian agencies, nearly enough to run the two-plot startup phase of the experiment, but he will need tens of millions of dollars more to expand to eight plots for another decade, as planned. Much of the money will go to CO_2, Lapola says: With the gas constantly escaping into the sky and surrounding forest, each treatment plot will need about 3.7 metric tons of CO_2 per day, or about 1350 tons a year, at up to $1000 a ton. The 2-year startup phase of the experiment has budgeted $1.3 million for the gas alone.

Results should start coming in 6 months after AmazonFACE begins, Lapola says, but it will take years for some effects of higher CO_2 levels to become apparent. Richard Norby, a U.S. biologist from Oak Ridge National Laboratory in Tennessee and veteran FACE researcher who was at the Manaus meeting, says the results might dash hopes that the Amazon forest will provide the longed-for carbon sponge.

Norby's own experiment on a sweetgum plantation in Tennessee and studies in other forests have shown that trees exposed to elevated CO_2 initially grow faster and sequester more carbon. But sometimes the beneficial effect abates within a few years, for reasons not yet clear. Norby says he expects a similar result in the Amazon. Like many other researchers, he thinks that a lack of phosphorus—a critical plant nutrient—in most Amazon soils will limit tree growth there, no matter how much CO_2 is present in the air. In the long term, he told his colleagues on the drive from the research site to Manaus, "I don't expect the extra carbon will do didley in this system." ■

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PHOTO: ITER COLLABORATIVE/EJF RICHE

FUSION ENERGY

More delays for ITER, as partners balk at costs

Review warns that new timeline could still be too optimistic

By **Daniel Clery** *and* **Adrian Cho**

It wasn't the pat on the back that ITER officials were looking for. Last week, an independent review committee delivered a report that was supposed to confirm that ITER, the troubled international fusion experiment under construction in Cadarache, France, finally has come up with a reliable construction schedule and cost estimate. But the report says only that the new date for first operations—2025, 5 years later than the previous official target—is the earliest possible date and could slip. And it underscores the challenge of ITER's ballooning budget. To start running by 2025, ITER managers have asked for an extra €4.6 billion, which they are unlikely to receive. As a result, the report says, ITER's ultimate goal—producing a "burning plasma" reaction of deuterium and tritium nuclei that sustains itself mostly with its own heat—will be delayed from 2032 until 2035 at the earliest.

ITER officials say the report confirms that the project is finally on the right track. "There is now a credible estimate of the schedule and cost envelope with respect to the financial capabilities of all the members," says ITER Director-General Bernard Bigot. "All the pieces are in place to make a decision" on enacting the plan. But others say that the new schedule is implausibly optimistic. "It's all fiction," says one expert who requested anonymity to protect his connections to the project. "As the report very carefully lays out, there are umpteen assumptions that aren't going to happen."

Dreamed up in the 1980s, ITER aims to show that deriving energy from nuclear fusion is feasible. Specifically, it aims to produce a burning plasma, trapped in an intense magnetic field, that will generate 10 times more energy than it consumes. In France, the project site is finally taking shape, as workers erect the massive facility's buildings and install the first components shipped from member states. About 40% of the work needed for first operations is done.

But delays and cost overruns have plagued ITER from the beginning. When the project partners—China, the European Union, India, Japan, Russia, South Korea, and the United States—signed the construction agreement in 2006, ITER was supposed to be finished this year for about $11 billion. The actual cost, impossible to calculate exactly because members contribute mostly parts rather than cash and use different accounting systems, could be three times as high.

ITER's woes stem from two sources, experts say. First, its design was far from complete when the agreement was signed. In fact, the report says, it's still not complete. Second, the ITER agreement established a weak central organization with little power to direct the project. Those management deficiencies were laid bare in a February 2014 review that called for 11 reforms, including the appointment of a new director-general and the completion of a realistic "baseline"

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