Dry Amazon could see record fire season

Forecasters warn that high ocean temperatures presage intense blazes in rainforest.

Jeff Tollefson

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Most fires in the Amazon are started by landowners trying to clear fields and forests for cultivation.

The Amazon is ready to burn. After an unusually dry rainy season, the southern section of the rainforest is heading into winter with the largest moisture deficit since 1998. This has set the stage for an unusually intense fire season, according to a forecast issued on 29 June that is based on sea-surface temperature trends in the Atlantic and Pacific oceans.

“The region is primed to have record fire activity,” says forecast co-author Douglas Morton, a remote-sensing expert at NASA’s Goddard Space Flight Center in Greenbelt, Maryland. More broadly, a team led by Morton and James Randerson, a biologist at the University of California, Irvine, says that it can predict fire risk across much of the globe — based in part on the influence of the weather pattern El Niño and its counterpart, La Niña.

The Amazon burn predictions stem from the epic El Niño weather event that emerged last year. El Niños warm the tropical Pacific Ocean, which tends to reduce rainfall during the rainy season, and the warmer temperatures in the tropical Atlantic Ocean can suppress rains during the dry season.

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The El Niño that emerged last year also helped to spawn devastating forest fires in Indonesia, the researchers say. Their work reveals that sea-surface temperatures in the Atlantic and Indian oceans foreshadow fire trends in Central America, Africa and some boreal forests in Earth’s high northern latitudes.

In each case, Morton and Randerson say, ocean conditions can provide a hint of precipitation trends in key forested areas on land several months in advance. “All of these processes are contributing to both the build-up of fuels and the moisture level of those fuels going into the dry season,” Randerson says. “That’s what leads to a predictability in global fire regimes.”

Forecasting vulnerability

Other teams are looking to include fire risk in short-term and seasonal weather forecasts by incorporating independent fire models. These models attempt to account for factors such as vegetation type and the likelihood of lightning strikes or agricultural fires. Eventually, such forecasting systems could integrate more complex phenomenon such as the dynamics of vegetation growth, the way that fire tends to propagate across a landscape and the gases and particles that are emitted during a fire, says Allan Spessa, a fire modeller at the Open University in Milton Keynes, UK.

The European Centre for Medium-Range Weather Forecasts in Reading, UK, plans to soon make public its prototype system to forecast fire risk about six weeks in advance, and the centre’s modellers are working to include fire risk in their seasonal forecasts. Florian Pappenberger, who heads the centre’s work on extreme-weather forecasting, says that the statistical approach used by Morton and Randerson is solid and can serve as an independent check on model forecasts, which come with their own uncertainties. Forecasts for water availability in rivers, reservoirs and agricultural systems operate in such a manner today.

“I don’t think one method replaces the other,” he says. “I expect that merging both will be quite beneficial.”

However, whether forests actually go up in smoke depends on a host of factors, including law-enforcement and fire-suppression efforts that vary from region to region. For instance, almost all fires in the Amazon are started by landowners clearing fields and forests for cultivation and livestock. But once the humidity drops and the vegetation dries out, those agricultural fires can run wild.

Ready to burn

The likelihood that this will happen increases as the dry season wears on, but scientists can already see El Niño's impacts. Morton and Randerson's team analysed rainfall measurements from gauges and satellites during the rainy season, and used data from NASA's Gravity Recovery and Climate Experiment (GRACE) satellites to provide an estimate of the cumulative water storage on land — in soils, aquifers and rivers — going into the dry season. Randerson says that the situation in the Amazon is worse than it was during the major droughts of 2005 and 2010 and on par with 1998, after the last major El Niño.

As well as forecasting risk in the Amazon, Morton and Randerson are tracking and mapping fires there using infrared measurements collected by the Moderate Resolution Imaging Spectroradiometer (MODIS) sensors aboard NASA's Terra satellite. The device has detected almost 12,500 fires in the Mato Grosso region of Brazil this year alone — making 2016 the third-worst year in the MODIS record, which stretches back to 2003.

In the Amazon, the question now is whether Atlantic storm systems will bring much-needed relief during the dry season. Morton and Randerson have identified a link between Atlantic hurricanes and Amazon fires: when the tropical Atlantic is warm, cyclones are more likely to form, and those cyclones pull the rain bands that often flow into the Amazon northwards. The US National Oceanic and Atmospheric Administration's hurricane forecast currently calls for a neutral season, but the tropical Atlantic has been cooling, which bodes well for the Amazon.

"If there were to be a shift in north Atlantic sea-surface temperatures, that could short circuit this fire forecast," Morton says.

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Deforestation: Carving up the Amazon

A rash of road construction is causing widespread change in the world's largest tropical forest — with potentially global consequences.

Barbara Fraser

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The Interoceanic Highway has spurred deforestation in the Peruvian Amazon.

Next to a newly paved highway in the Peruvian Amazon, a discreet white-on-green sign urges travellers to protect the surrounding ecosystem. “Let's care for the environment, let's conserve the forest,” it reads. But the appeal comes too late for this spot in the region known as Madre de Dios. Before the route was paved a few years ago, tall trees lined the roadside, but the forest edge here now lies about half a kilometre away, beyond a jumble of underbrush and freshly cut trees where a cattle pasture was recently carved out of the woods.

As drivers head east and enter Brazil, the view is much the same for hundreds of kilometres. Such is the impact of the Interoceanic Highway, a route some 5,500 kilometres long that cuts clear across South America.

The highway is just one strand in a web of roads that now criss-cross the

Amazon. So far, most have encroached on forest around the edges of the basin, but they are increasingly slicing through the middle. In Brazil alone, the Amazon road system grew by an average of almost 17,000 kilometres a year between 2004 and 2007 (ref. 1). Across the basin, estimates for the total length of roads vary widely from about 100,000 to 190,000 kilometres of paved and dirt roads cutting through the Amazon.

Once construction begins, road crews are quickly followed by land speculators, loggers, farmers, ranchers, gold miners and others who carve away the forest along the route. That activity leaves obvious scars on the landscape in the form of treeless expanses, but research is now showing that the building of roads also triggers a cascade of environmental changes in the remaining forest that can dry out trees, set the stage for wildfires and weaken the ecosystem.

“Put a road into a frontier area and it opens a Pandora's box,” says biologist William Laurance of the Centre for Tropical Environmental & Sustainability Science at James Cook University in Cairns, Australia.

The drying brought about by roads influences local atmospheric circulation patterns and can have farther-reaching effects that not only compromise the health of the Amazon but can also contribute to global warming by releasing carbon stored in the forest. Understanding those details is crucial, researchers say, for determining whether these effects — combined with severe droughts such as those that struck parts of the Amazon basin in 2005, 2007 and 2010 — could tip the world's largest expanse of tropical forest from being a net absorber of carbon dioxide to a net emitter[2].

The first cut

It was a road that kicked off the pattern of destruction in the Amazon forest. In the 1970s, Brazil began building the Trans-Amazonian Highway from near the country's easternmost point on the Atlantic coast to its western border, where the state of Amazonas meets Peru. The route opened up the heart of the Amazon to logging, ranching and settlement, causing deforestation rates to soar. Extreme spells in the 1990s and early 2000s claimed more than 25,000 square kilometres a year — an area bigger than New Jersey. Since 2005, government measures, including crackdowns on illegal logging, have slowed forest loss. Throughout, roads have provided the means to penetrate the forest and erase large chunks of it. In an unpublished study of the Brazilian Amazon, Christopher Barber, a researcher at South Dakota State University in Brookings, found that 95% of deforestation in the region occurs within 7 kilometres of a road. And that is not the only problem: just as serious as outright deforestation is fragmentation, which happens when loggers, ranchers and farmers move in. In Brazil, up to 38,000 kilometres of new forest edge are created each year[3].

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Roads cause drying within the forest, making them more susceptible to burning.

Standing in a field in the western Brazilian state of Mato Grosso, Michael Coe can feel the difference that deforestation makes in the Amazon. An atmospheric scientist who heads the Amazon programme of the Woods Hole Research Center in Falmouth, Massachusetts, Coe is visiting an 80,000-hectare patch of former forest that was originally cleared some years ago to build a cattle ranch, which later morphed into a soya-bean farm. The air is noticeably hotter and drier in the field than in one of the few patches of forest left on the farm.

Coe and his colleagues are here to study how forest degradation and fires alter the flow of water and energy in the Amazon ecosystem. Evapotranspiration from trees provides moisture to the air and feeds much of the precipitation in the Amazon: when the trees disappear, so does a major source of moisture. A study using satellite data and models of atmospheric circulation suggests that air passing over tropical regions rich in vegetation produces at least twice as much rain as air moving over areas with little vegetation[4].

Stripping away trees not only eliminates a source of moisture; it also changes the regional air flow. Heat rising from a bare field creates a low-pressure system that pulls in air from the surrounding area, sucking moisture out of the nearby forest, says Coe.

“We're looking at a tidal wave of road expansion happening in the next few decades.”

As the forest dries, it transfers less moisture to the atmosphere, changing rainfall patterns hundreds or thousands of kilometres downwind. That could affect not only forests and agriculture across the basin, but also the amount of water available to power hydroelectric dams. In a simulation using climate, hydrological and land-use models, Coe and his colleagues projected that reductions in rainfall caused by deforestation could drastically cut the power-generating capacity of Amazonian dams[5]. That would upset the plans of Brazil, Peru and Ecuador, which intend to increase hydropower to meet rapidly growing electricity demands.

The drying effect reaches well past the forest's edge. And the more fragmented the forest, the wider the impact, according to one study that found canopy drying 2.7 kilometres from the edge of a highly fragmented forest[6].

The influence of roads in the Amazon could even reach around the world. Recent lines of research suggest that changes in several factors prevent trees in disrupted forests from storing as much carbon as they did in the past, a shift that could accelerate global warming.

Greg Asner, a tropical ecologist at the Carnegie Institution for Science at Stanford University in California, studies the chemistry of the tree canopy in the Amazon using ground plots and airborne spectrometers. He is finding that the forest canopy along the edges of open patches does not seem to hold as much water or pigment, such as chlorophyll, as trees in unbroken parts of the forest. “Not enough chlorophyll and not enough water keep the canopy from soaking up carbon dioxide at the rate that we know it can, compared to the more interior forest,” he says.

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Patches of cleared land border the Interoceanic Highway as it runs through the Amazon.

Line of fire

Changes in the Amazon's fire potential are also impeding the forest's ability to store carbon. Conventional wisdom has long held that the rainforest was too humid to burn. But in 2005, when drought struck the western Amazon, wildfires in the Brazilian state of Acre merged into a line 11 kilometres long, with flames leaping to canopy height, recalls Foster Brown, an environmental geochemist at the Woods Hole Research Center who witnessed the fires.

The flames damaged more than a quarter of a million hectares of forest in that state alone and caused US$100 million in damages. Smoke blanketed Rio Branco, the state capital, and public-health concerns finally led to ordinances to control burning during times of drought.

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Scientists considered the 2005 drought to be a once-in-a-century event; some 70 million hectares of forest suffered water stress[7], and there was significant drying within the tree canopy. But five years later, a similar dry spell struck, triggering another extreme bout of fires. Because they have not evolved in an environment frequently beset by fires, trees in the Amazon forest are susceptible to heat and damage from flames.

Farther east, in Brazil's Xingu region, researchers saw similar results from experimental fires during a drought in 2007. Tree mortality from heat and fire damage that year was more than four times that of a normal year[8], especially along the forest edge, which the researchers burn every three years in a cycle emulating traditional Amazonian agricultural practices, says ecologist Paulo Monteiro Brando of Brazil's Amazon Environmental Research Institute in Brasília. In the Amazon, burning is the cheapest and most effective way for farmers to clear fields and give them a nutrient boost before planting crops, or rid them of ticks that plague livestock.

Understanding the future of the Amazon means learning how to model not just physical and atmospheric processes, but also how humans are changing the land, researchers say.

And as the wider impact of Amazonian roads becomes clearer, planners and conservationists face a dilemma. Although roads threaten the forest's health, they also significantly lower costs for farmers and businesses, and can make a difference between life and death for people in remote areas far from hospitals.

But unrestricted road building could lead to irreparable environmental harm, say researchers. “We're looking at a tidal wave of road expansion happening in the next few decades,” Laurance says. “It's ecological Armageddon, and it's happening again and again.”

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