

Mongabay Series: Amazon Conservation

Impending Amazon tipping point puts biome and world at risk, scientists warn

by Shanna Hanbury on 27 January 2020



- *Climate models coupled with real world biome changes are causing prominent scientists to forecast that, unless action is taken immediately, 50 to 70% of the Amazon will be transformed from rainforest into savanna in less than 50 years.*
- *That ecological disaster would trigger a vast release of carbon stored in vegetation, likely leading to a regional and planetary climate catastrophe. The Amazon rainforest-*

deforestation, regional and global climate change, and increasing Amazon wildfires — all of which are making the region dryer.

- *While models produced the first evidence of the tipping point, events on the ground are now adding to grave concern. The Amazon has grown hotter and dryer in recent decades, and rainforest that was once fireproof now readily burns. Plant species adapted to a wet climate are dying, as drought-resistant species flourish. Deforestation is escalating rapidly.*
- *Scientists say the tipping point could be reversed with strong environmental policies. However, Brazilian President Jair Bolsonaro is moving in the opposite direction, with plans to develop the Amazon, including the opening of indigenous reserves to industrial mining and agribusiness, and the building of roads, dams and other infrastructure.*



Amazon trees may not die immediately in a severe drought, but weakened trees can die off many years afterward, even

"We're on the edge of a cliff," says top climate scientist Carlos Nobre, who published an editorial (<https://advances.sciencemag.org/content/5/12/eaba2949>) with renowned conservation biologist Thomas Lovejoy last month warning that "The Amazon tipping point is here."

Many scientists who study the Amazon rainforest are very worried. The tropical biome over recent decades has grown increasingly dryer (<https://www.nature.com/articles/s41598-019-51857-8>), making the once nearly fireproof rainforest prone to raging wildfires. Extreme weather events, such as high heat, droughts (<https://news.mongabay.com/2018/08/from-sink-to-source-droughts-are-changing-the-amazon-rainforest/>) and floods (<https://news.mongabay.com/2018/12/extreme-floods-on-the-rise-in-the-amazon-study/>), are on the rise. The dry season is getting longer and hotter

(<https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/2018JD029537>) and trees are dying (<https://onlinelibrary.wiley.com/doi/full/10.1111/gcb.14413>). Computer models show that all this could be a foreshadowing of far worse to come — potentially, a recipe for a tropical rainforest disaster.

But what exactly is the Amazon tipping point (<https://e360.yale.edu/features/amazon-watch-what-happens-when-the-forest-disappears>)?

What might it look like, and when might it happen? And how might it occur: will the tipping point occur as a gradual downhill decline, or sudden freefall? Mongabay spoke to several leading scientists to find out.

The Amazon rainforest, as its name suggests, is historically a rainy, humid, green place. In its natural state even lightning wasn't enough to start a fire there — the vegetation was simply too wet for ignition. But today, this is no longer true over much of the region.

Researchers say the very wet hydrological cycle that kept the rainforest thriving for millennia is under threat, with the biome

escalating climate change.

These trends may not be irreversible: Human activities — deforestation versus reforestation of native vegetation, for example — have the potential to either push the Amazon over the brink to a new ecological paradigm, or possibly tip it back toward its original state.



In the past, IBAMA, Brazil's environmental agency led crackdowns on illegal mining and deforestation. But under President Jair Bolsonaro, IBAMA has been largely defunded and de-toothed. Deforestation in Brazil increased rapidly over the last year. Image by Ascom IBAMA/Fotos Públicas.

Rapid progress toward a tipping point

According to the tipping point theory, large parts of the Amazon rainforest today are on the verge of dying back into a drier, degraded savanna or shrubland. Some researchers, like Nobre, are sure we're on the edge of a dangerous precipice. Others aren't convinced it's so near, but don't deny an eventual biome transition.

holds a vast store of carbon in its plants and soil; so a transition to degraded savanna would not only be a disaster for the region's biodiversity, and its indigenous and traditional peoples who rely on it for their livelihoods; the forest-to-savanna conversion, especially if it happens quickly, could tip atmospheric carbon emissions deep into the danger zone, leading to global climate catastrophe.

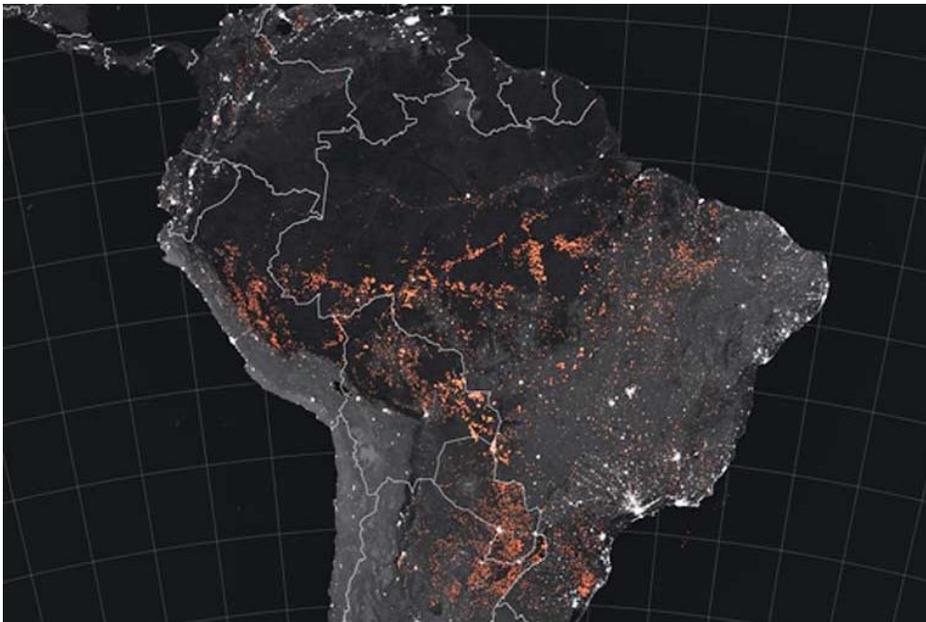
Unfortunately, worsening deforestation — which models say could more rapidly bring on the tipping point — is currently trending in the Amazon basin: Brazilian President Jair Bolsonaro, in office since January 2019, is pressing ahead with his Amazon exploitation agenda. According to draft legislation (<https://uk.reuters.com/article/us-brazil-indigenous/amazon-tribes-gather-to-plan-resistance-to-brazil-government-idUKKBN1ZD2HQ>) seen by Brazil's O Globo newspaper, the Bolsonaro administration wants to open indigenous reserves to industrial mining, as well as oil and gas exploration — development currently banned by law — while also building new hydroelectric dams and expanding agribusiness.

In the first year of Bolsonaro's rule, Brazil's deforestation rate soared to an 11 year high (<https://news.mongabay.com/2019/11/amazon-deforestation-rises-to-11-year-high-in-brazil/>), and environmental protections were severely cut back (<https://news.mongabay.com/2019/12/bolsonaros-brazil-2019-brings-death-by-1000-cuts-to-amazon-part-one/>). Hopes of the country reaching its Paris Agreement carbon reduction goals (<https://news.mongabay.com/2019/09/bolsonaros-brazil-unlikely-to-achieve-paris-agreement-goals-experts/>) are fading, as the president puts forward plans for new Amazon roads, dams (

transmission lines

(<https://news.mongabay.com/2019/11/brazil-works-behind-scene-to-greenlight-manaus-boa-vista-transmission-line/>).

Those actions have scientists alarmed: if the Amazon overshoots the critical tipping point, it would mean a massive die off of Amazon vegetation that could send billions of tons of carbon skyward — just as the world is scrambling to curb greenhouse gas emissions.



Amazon wildfires occurring August 15-22, 2019. Recent studies have found that events on the ground fulfill forecasts made by climate models: The Amazon is getting progressively dryer, leading to far more numerous wildfires. However, those fires typically are in edge areas where the rainforest is under pressure from agribusiness. Image courtesy of NASA/Fotos Públicas.

A rainforest without rain isn't a forest

The first signs of a forest-to-savanna shift — propelled by a changing climate, accelerating deforestation, and increased wildfires — are beginning to show up on the ground, according to Nobre. The tipping point is “no

had based his forecasts on climate models. After signs of a changing Amazon were revealed by several biome studies over the last two years, Nobre and Lovejoy decided to up the ante on their previous forecast.

(<https://news.mongabay.com/2018/03/amazon-forest-to-savannah-tipping-point-could-be-far-closer-than-thought-commentary/>) What they had predicted via climate models, was now happening in real-time, and far faster than expected.

Nobre now projects that 50 to 70% of the Amazon will become savanna in less than 50 years. "For over half of the Amazon to become a degraded savanna in 50 years — that is falling off a cliff," Nobre warns. "In evolutionary biology, it's a snap."

At the heart of this forecast, and a major factor in Nobre's and Lovejoy's upgraded warning, is a landmark scientific report

(<https://onlinelibrary.wiley.com/doi/full/10.1111/gcb.14413>) from a long-term international scientific collaboration known as RAINFOR, which collected data from 106 different Amazon one-hectare (2.5 acre) plots over three decades. The study, led by ecologist Adriane Esquivel Muelbert of the University of Birmingham, shows that species adapted to a wet rainforest climate are dying while drought-resistant species are on the rise.

"Our project was quite conservative. We didn't take samples from deforested areas," Muelbert told Mongabay. "This is why it's so worrying. Even in the most remote corners of the planet, we are seeing the human impacts."

A NASA study

(<https://www.nature.com/articles/s41598-019-51857-8>) published in October 2019 co-authored by Sassan Saatchi and Armineh Barkhordarian corroborates these findings. Humidity is decreasing across the region, their

20-30% over the last three decades.

This real-world data points to a knock-on effect: a positive feedback loop long seen by scientists in their models, which has begun pushing the Amazon to the tipping point.

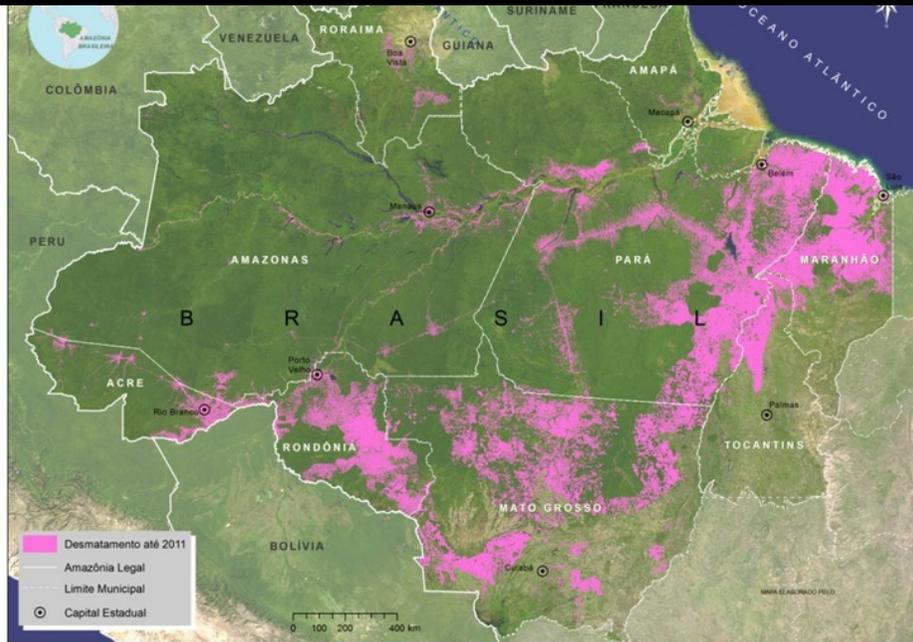
"Even the Northwest [Amazon], which is supposed to have huge resilience and lush rainfall is being impacted," Saatchi reveals; drying effects began showing there after the 2005 drought. In the Southeast Amazon — a region with far greater deforestation — drying tendencies have been tracked since the early 1990s.

"It's extremely alarming." Saatchi says.

Impacts are now being seen at all levels: Tree canopies and leaves are getting warmer and the air around them less humid. The soil below, increasingly parched by long-term drought or washed out by intensifying floods, holds less water to feed roots. "In rainforest areas, length of dry season has increased by 5-7 days per decade consistently over the last 30 years," reports Saatchi.

Trees act as pumps, sending water from the ground back toward canopy leaves, then into the sky, keeping the atmosphere humid and recycling rain across the Amazon forest. Since trees regulate climate, and climate affects trees, small changes in either can create a domino effect.

According to scientist and United Nations Intergovernmental Panel on Climate Change (IPCC) researcher Marcos Heil Costa, the Amazon rainforest needs at least seven months of rain to thrive. "Six months rain and you have a savanna," he says. However, Costa's research (<https://rmets.onlinelibrary.wiley.com/doi/abs/10.1002/joc.6335>) shows that over the last decade, the wet season has been starting late and the dry season is coming early.



The Arc of Deforestation in the Brazilian Amazon — a vast swath of former rainforest intruded on by roads, dams and mines, and converted to cattle ranches, soy plantations and other monoculture croplands. Image by KBHS Social Sciences.

It's in the more deforested Southern Amazon that this drying effect is most dramatic, Costa told Mongabay, pointing to two (<https://rmets.onlinelibrary.wiley.com/doi/abs/10.1002/joc.6335>) studies (<https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/2018JD029537>) published in 2019. Some areas there are already approaching the six-month rainforest-to-savanna threshold. "This is evidence that the conditions for a tipping point are being satisfied," he says.

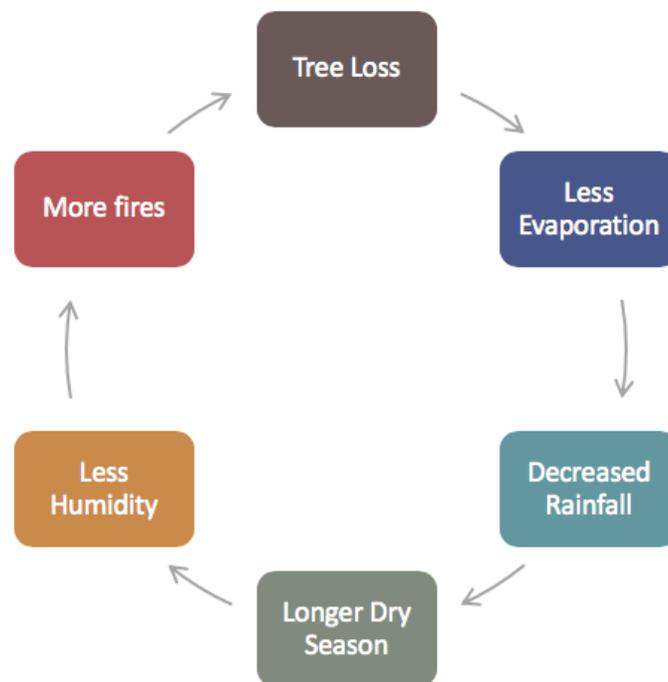
Amazon areas heavily impacted by ranching, logging and land grabbing are also typically closer to the neighboring already-dry Cerrado savanna, putting them at a natural disadvantage. Meanwhile, the so-called Amazon Arc of Deforestation — a vast crescent shaped swathe of tree loss sweeping from Pará and Maranhão states in Brazil's East, through Mato Grosso state, to Rondônia and Acre — is pushing relentlessly northward.

Rainforest isn't only at risk from the drying. Agriculture, critical to Brazil's economy, Costa says, is already affected: "If you talk to any farmer in Mato Grosso [state], they'll tell you

(<https://news.mongabay.com/2018/03/cerrado-agribusiness-may-be-killing-brazils-birthplace-of-waters/>) too, which is extremely bad news for Brazil's great Eastern cities which rely on both biomes for their water supply.

Dry conditions in the degraded Southeastern Amazon are resonating westward into largely forested regions — the most crucial for delaying positive climate feedbacks adding to the drying. “The moisture and the airmass is moving East to West,” says Lovejoy. “So it’s the deforestation in Brazil that makes the biggest difference,” for forested Amazon areas farther west. Total forest loss in the Brazilian Amazon since 1970 totals 718,927 km² (https://rainforests.mongabay.com/amazon/deforestation_calculations.htm) (277,579 square miles), an area larger than France that grows bigger with each passing year.

But what still isn't precisely known is at what point climate change and tree loss combine to be self-propagating — a process that drives itself without further need of human forcing — resulting in an unstoppable death spiral that rushes onward until the Amazon as we know it ceases to exist.



Once Amazon rainforest conditions are degraded sufficiently due to human causes, a self-propagating “natural” cycle takes over. The challenge for scientists is

Uncertainty and a “call to action”

As dire as all of this sounds, scientists aren't certain in their tipping point calculations. Previously, climate models predicted a tipping point — based solely on total deforestation — would be reached when 40% of the total Amazon was deforested. But after adding in the impacts of climate change and Amazon fires, that prediction was halved to 20-25%. Today, an estimated 17% of the Amazon's original total forest cover has been lost. As things now stand, regional and global climate change are believed to be roughly matching deforestation in their Amazon impacts. However, new queries about tree resilience, reactions to CO², root systems and the behavior of wildfires are complicating, and refining the equation.

“The tipping point is something we worry about a lot. But we are [still] not completely sure how the mechanisms would work,” confesses NASA's Sassan Saatchi. “Our ecosystem models are not completely equipped to simulate this for us. Some show a drastic dieback of trees, others show more flexibility and resilience.”

A 2013 climate model simulation (<https://www.nature.com/articles/ngeo1741>), for example, found surprising resilience from rainforest vegetation that benefited from the growth spurt brought on by higher atmospheric CO² levels. One of the study's authors, Peter Cox, published a landmark paper (<https://www.nature.com/articles/35041539>) in

off from that conclusion.

Adriane Muelbert cautions against relying too heavily on climate models, which always are limited by their inputs, so necessarily imperfect. Models, she says, do not carry the same scientific weight as real-life observations which prove a dieback has already begun.

Several researchers told Mongabay that today's climate models need to be improved, with new inputs, before they can accurately represent the dynamics and timing of the Amazon tipping point, and they stressed the need for new investments in science and technology. "We need models to answer the new questions we have today. Twenty years ago savannization was a mere possibility. Today, we have evidence that the forest is already on this path. But the models are becoming obsolete," says Costa.

Others view the emphasis on the tipping point as counter-productive because it could trigger a feeling of helplessness with the public.

"Embedded in the Amazon tipping point hypothesis is a fatalism that sends the wrong message — that there is no turning back," cautions Daniel Nepstad, president of the Earth Innovation Institute (<https://earthinnovation.org/>).

Oxford University professor and rainforest expert Yadvinder Malhi echoes this view:

"There's a feeling that it's inevitable. That we're doomed. I don't think we're there. There's a lot that can be done. Rather than despair, I think it's a call to action to avoid these worst-case scenarios."

As of this moment, the question remains as to whether the first danger signs now evident will result in half the rainforest eventually turning into a degraded savanna or grassy scrubland, or if the forest will respond differently to the

interviewed for this story agree: the earth's most intact rainforest is clearly in danger.

"My sense is that the changes you are seeing in the Southern Amazon are a prelude," Lovejoy says. "You'll see a lot more fire, a lot of dead vegetation. It will get a lot drier. It's not a pretty picture, even though you can't be too definite about it."

And simply sitting back and waiting for real-life observations to confirm an Amazon tipping point, he says, is an "unthinkable" experiment.



The Amazon rainforest on fire. In extreme droughts, fire spreads rapidly, causing widespread destruction. In the past, the rainforest was too wet to burn. Almost all rainforest fires in Brazil today are set by humans seeking to convert forest into grazing and croplands. Image by Paulo Brando/IPAM.

Fire in a tropical rainforest no longer a paradox

When Ane Alencar, now the science director at the Amazon Environmental Research Institute (IMPA), started to research fire in the Amazon a quarter century ago, she was largely

simply put, there weren't many. "This was new," she recalls, "It's a very strange phenomenon."

Naturally, an Amazon fire cycle should happen only once every 500 to 1,000 years, Alencar explains. But recently in the Eastern Amazon — a region with high levels of land clearing — she has found areas that are burning every three years. "Parts of the Amazon are already at this point of auto-destruction," she asserts. "The system can no longer sustain itself. The drier it is, the more fire there is, and the more fire there is, the drier it gets," and so on.

A study

(<https://advances.sciencemag.org/content/6/2/eaay1632/tab-article-info>) published in January 2020 by IMPA researcher Paulo Brando estimates that the area of the Amazon burned by wildfires could reach 16% of the forest by 2050.

"Aggressive efforts to eliminate ignition sources and suppress wildfires will be critical to conserve Southern Amazon forests," his report states.

These fires look different than the gigantic blazes that occur in temperate regions. And unlike fires on cleared land, wildfire in standing tropical forests often go undetected, smoldering beneath the canopy. But by degrading the forest, they worsen future fires (<https://onlinelibrary.wiley.com/doi/pdf/10.1111/gcb.14872>).

During the intense 2015 El Niño drought, Nepstad says that exactly this sort of under-canopy wildfire burned through an Amazon area of standing forest in the Northeastern Santarém region larger than the area deforested that entire year in the biome.

"It's all a question of how frequent and intense those really severe draughts are," Nepstad told Mongabay. "And when they [do] hit, are there sources of ignition? That's a huge opportunity for us." By preventing ignition and boosting

contained.

But such policies require political will. And so far, under Bolsonaro, policy is moving in the opposite direction, with the gutting (<https://news.mongabay.com/2019/06/brazil-guts-environmental-agencies-clears-way-for-unchecked-deforestation/>) of environmental agencies responsible for fighting wildfires and illegal deforestation. In 2019, Brazil's fire prevention program was slashed by 50% as part of a 45 million dollar (187 million reais) budget cut to the Ministry of Environment, according to a report (<https://www.oeco.org.br/noticias/governo-corta-r-187-milhoes-do-mma-saiba-como-o-corte-foi-dividido/>) by O Eco, a Brazilian environmental news website.

"The amount of fire ultimately depends on ignition. And ignition is sparked by humans and very much signaled by politics," says Alencar. Most Amazon fires are set by landholders and are not due to natural causes. "The [Brazilian] government needs to grasp the value of the Amazon. It makes me sad that we are throwing this away."



Irreversible damage across the world

Even as the tipping point debate continues, there is expert consensus on one fact: The death of billions of Amazon trees would release enormous quantities of carbon into the atmosphere, undoing global emissions reduction goals, raising planetary temperatures, and causing more extreme weather events.

A massive Amazon die off might also trigger knock on impacts in other biomes and ecosystems. A recent study, for example, found that Amazon fires are melting Andean glaciers

(<https://www.nature.com/articles/s41598-019-53284-1>). But it isn't known exactly how Amazon forest-to-savanna conversion — with giant carbon releases — might force other global biome tipping points.

"When you take the Amazon away, the effects are felt in far-flung parts of the planet," says Timothy Lenton, a professor at the University of Exeter who studies the connections between the earth's different tipping points (<https://www.nature.com/articles/d41586-019-03595-0>). "It could mean that other places far away will get wetter or drier as the circulation of the atmosphere reorganizes itself."

It is thought that savannification of the Amazon biome would be permanent

(<https://news.mongabay.com/2019/08/deforestation-climate-crisis-could-crash-amazon-tree-diversity-study/>): "Biodiversity will diminish drastically and

survive. It's a process of natural selection."

To avoid the Amazon tipping point, Brazil's government needs to step up, says Monica deBolle, an economist and environmental policy advisor at the Peterson Institute of International Economics. "We need a government that is making an active effort to protect the Amazon, which hasn't been the case under Bolsonaro."

But the international community, she says, with its own climate emissions problems (which in turn impact the Amazon), must step up too. "Attacking the Bolsonaro administration, as some governments have done, without considering cooperation and the provision of incentives to avert deforestation, has put Brazil's government in a confrontational position which does not serve anyone's interests," deBolle wrote in an October 2019 policy brief (<https://www.piie.com/sites/default/files/documents/pb19-15.pdf>).

Nobre and Lovejoy, the chief proponents of the tipping point theory, still have hope for a sustainable future despite their forecasts. "The time to act is now," they told Mongabay, urging politicians to have a change of heart. They prescribe ambitious reforestation goals in order to save the Amazon, along with the transformation of industrial agribusiness practices, including the adoption of best practices that allow for the intensification of beef production on already degraded lands and the elimination of vast monoculture plantations of soy and sugarcane.

For Lovejoy, there is a silver lining in abandoned land plots that are recovering naturally; he notes that a quarter of Brazil's 16-20% lost tree cover has been deserted and is now growing back.

"The only sensible way forward is to launch a major reforestation project especially in the Southern and Eastern Amazon," the two scientists write in Science

"The good news is that we can build back a margin of safety."

The scientific community still has plenty of disagreements concerning the tipping point. But when it comes to the urgent need to reduce deforestation, fight wildfires and invest (<https://www.nature.com/articles/d41586-019-03169-0>) in science, while preserving Amazon biodiversity and achieving global carbon reduction goals, they are unanimous. The time to act, is now.

Banner image caption: Amazon trees killed by drought. Image courtesy of NASA/JPL-Caltech/Fotos Públicas.

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