# The world is 'perilously close' to irreversible climate change. 5 tipping points keep scientists up at night

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Five years ago, the United Nations' panel on climate change was charged with drafting a series of reports detailing its science, the effects on the

planet and how humanity might save itself.

The last of those reports arrived this week, and the news is dire. The world's scientists say the crisis is upon us, and unless we act now, multiple crucial planetary systems are on the cusp of permanent damage.

"We can't kick this can down the road any longer," said Andrea Dutton, a geoscientist at the University of Wisconsin, Madison.

Since the 1880s, the Earth's temperature has risen more than 2 degrees, according to NASA. That may not sound like a lot, but it's enough to disrupt natural systems that support all living things—including humans.

In a damning speech Monday, U.N. Secretary-General António Guterres said the world is "perilously close to tipping points that could lead to cascading and irreversible" consequences.

Here are five tipping points scientists say could start to teeter in our children's lifetime:

## Amazon rainforest becomes a savanna

In most immediate peril is the Amazon rainforest.

The 2.5 million square mile rainforest is so vast it creates its own rainfall and is home to 10% of the world's species.

But rising temperatures and increasing drought are bringing it ever closer to crossing the threshold from lush rainforest to arid savannah.

"The recent evidence has been quite alarming. It really does look like we're closing in on a place where a relatively modest amount of drying could kill off the rainforest and turn it into something else," said Daniel

Swain, a climate scientist at the University of California, Los Angeles.

In part because of the increased heat and lack of rain, the Amazon is seeing more wildfires. These destroy large areas that grow back not as rainforest but as grasslands with few trees. Illegal logging to grow grass or soybeans to feed cattle exacerbates the problem.

A study published last month found signs of lost habitat in more than 75% of the rainforest since the early 2000s, A 2020 paper estimated as much as 40% of the existing rainforest might not grow back if destroyed.

## Coral reefs die

Coral reefs hang in the balance.

Coral are vital to the health of the oceans. Although they cover only 0.2% of the ocean floor, they are home to at least a quarter of all marine species. They provide safety for juvenile fish and are home to the small organisms and fish which provide food for larger fish. Scientists estimate that the reefs account for 25% of fish caught in developing countries.

Coral reefs can survive within only a relatively narrow temperature band. The coral that build them get much of their food from algae living in their tissues. When the seawater is too warm, the coral's stress response is to expel algae, causing the coral to turn white. The process is called coral bleaching, and if it lasts too long, the coral can starve—turning a thriving ecosystem into a cemetery of dead shells.

A report released last year showed that almost 15% of the planet's reefs have vanished since 2009, primarily because of climate change.

"They're being cooked to death," said Dutton, a MacArthur Genius Award winner, who studies the deep history of the oceans.

"The frequency at which we're seeing these bleaching events is astounding to those of us who study them," she said. "It's going to have a huge domino effect on marine systems and on humans."

## Ice sheets melting

Time is running out for the world's largest ice sheets.

Both the Antarctic and Greenland ice sheets are melting, and the Antarctic is believed to be the most unstable.

If they melt entirely, it would cause catastrophic sea level rise around the globe. Loss of the Antarctic sheet could result in as high as 11 feet of rise. Loss of the Greenland sheet could be 23 feet, said Timothy Lenton, chair of climate change and Earth system science at the University of Exeter, United Kingdom.

"About 90% of the transportation worldwide goes over the ocean and all port infrastructure is at sea level—you can see what a problem this will cause," said Peter Schlosser, director of the Global Futures Laboratory at Arizona State University.

Though the rise probably will take much longer, it could happen as quickly as 100 years from now for Antarctica and 300 years for Greenland, a paper by Lenton found.

"I know that might seem a long way off, but you'd be talking about having to move many coastal megacities in the next 100 or 150 years," he said.

## Atlantic circulation stops

The circulation of the Atlantic is at risk.

The official name of this danger is Atlantic Thermohaline Circulation Collapse. If it were to happen, it could bring about an ice age in Europe and sea level rise in cities like Boston and New York.

What's known as the Atlantic Meridional Overturning Circulation (AMOC) keeps warmer water from the tropics flowing north along the coast of northern Europe to the Arctic, where it cools and sinks to the bottom of the ocean. That cooler water is then pulled back southward along the coast of North America as part of a circular pattern.

This cycle keeps northern Europe several degrees warmer than it would otherwise be and brings colder water to the coast of North America.

There is some indication the system has experienced a gradual weakening over the past few decades, and it may be critically unstable.

Lenton's research suggests that if global temperatures continue to rise, the AMOC could collapse in 50 to 250 years.

The 2019 IPCC report suggested the AMOC will "very likely" weaken this century but has a less than 10% chance of collapsing.

But just the loss of a constant river of warmer water flowing toward Europe could lower temperatures there, strengthen hurricanes and raise the sea level along the northeastern coast of North America.

"You're not transporting as much water, so it gets backed up along the East Coast," Dutton said.

## The 'snow forest' disappears

The vast boreal forests of the north face a future as treeless grasslands.

Cold weather forests that run across the Western United States, Canada and Alaska are estimated to store more than 30% of all forest carbon on the planet. Without them, huge amounts of greenhouse gases would be released into the atmosphere, worsening global warming.

A combination of three things are destroying it: heat, fire and bark beetles. Rising temperatures cause droughts and make forest fires more likely. Heat also boosts the population of bark beetles devastating the forests.

"Forests can tolerate heat and drought up to a point, and then there's a point where they can't tolerate anymore," Swain said. "There's evidence that we're hitting that point or close to it."

Bark beetles are native to North America. In northern latitudes, when winters are cold and summers cool, they typically reproduce once a year. With warmer and shorter winters, they can reproduce twice, resulting in larger populations and more stress and tree death.

The dead trees become fire hazards, causing wildfires to burn larger and hotter. When the fire is gone, grasslands, not forests, can grow back.

"There are some trees that are well adapted to the harsh cold, but you've made the summers too hot for them, so they're replaced with a steppe grassland that can cope with the hotter summers," Lenton said.

## The time is now

Scientists and many of the world's political leaders are unequivocal: The time for action is now. Not next year, not a decade from now.

"The stakes are clear. Complacency will be met by irreversible and unthinkable impacts from climate change," John Kerry, the U.S. special presidential envoy for climate change, said Monday.

Any of these collapses, even if not total, would be bad for the planet, experts say. Even worse, as systems become unstable, they affect others, leading to more instability and potential collapse. Carbon currently stored in the earth would be released into the air, leading to more temperature rise and calamity.

In the face of these possibilities, it's vital that humanity avoid increasing the planet's temperature any more than it already has, experts say.

"We're approaching thresholds we really don't want to walk through," Schlosser said. "We're near the zone where the Earth is getting back at us."

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