



MARIO GYB/ALAMY

*Frailejones* shrubs (*Espeletia* spp.) in Los Nevados National Park, south of Medellín, Colombia.

# THE RACE TO UNDERSTAND COLOMBIA'S EXCEPTIONAL BIODIVERSITY

Scientists have discovered a wealth of new species since Colombia's civil war ended. But the bonanza might not last. **By Aisling Irwin**

Some 3,500 metres up in Colombia's Sumapaz mountains, the mist is rushing and the air is cold and thin. A thousand *frailejones* – plants of human height and girth – stand like silent guardians in the landscape, their thick brown stems and silver-green crowns like apparitions in the fog. This is the paramo, an ecosystem in the high Andes, where the strange shrubs are exquisitely adapted to the often-fierce ultraviolet radiation, low temperatures and high humidity. And in the past few years, this unusual environment has begun to give up its secrets.

Scientists have waited for decades to study the paramos and dozens of other ecosystems across Colombia. Until a few years ago, many of them were off limits because of civil war. When the government made peace with the main guerrilla force, FARC (the Revolutionary Armed Forces of Colombia), in 2016, huge tracts of unexplored forests, caves and mountains became accessible.

The years since then have been frenetic for Colombia's natural and social scientists, whose country is one of the most biodiverse in the world. The government has launched expeditions and research projects, sometimes recruiting former guerrillas as guides and citizen scientists; other countries have contributed funds and more research staff. With some major projects now publishing their final papers, researchers have described tens of thousands of species new to Colombia and hundreds new to science – increasing the number of known species in the country by 50%. Storage facilities are straining to accommodate the bounty of specimens and samples.

Colombia's national biodiversity database, SiB Colombia, has helped both scientists and citizens contribute to the effort. It has "been a shining example of how to gather biodiversity data", says Kyle Copas, a spokesperson for the Global Biodiversity Information Facility in Copenhagen, an international network that shares biodiversity data.

The findings signal a new era for Colombian ecology, says Mauricio Diazgranados, a Colombian botanist who led a number of the research projects on behalf of the UK Royal Botanic Gardens, Kew. "We are living in the spring, in terms of research interests in the country," he says.

Researchers are using the finds to explore genomics, evolution, geology, conservation and the interaction of Indigenous and local people and their environments, as well as assessing how to sustainably exploit Colombia's plant and animal riches.

But the buoyant mood might not last. Scientists have not been the only group to regain access to land: others have been claiming the space for cattle ranches, planting coca to produce cocaine or mining for coal or gold.

Meanwhile, violence still stalks the country and some researchers fear they might lose the precious access they have enjoyed.

### Diverse patchwork

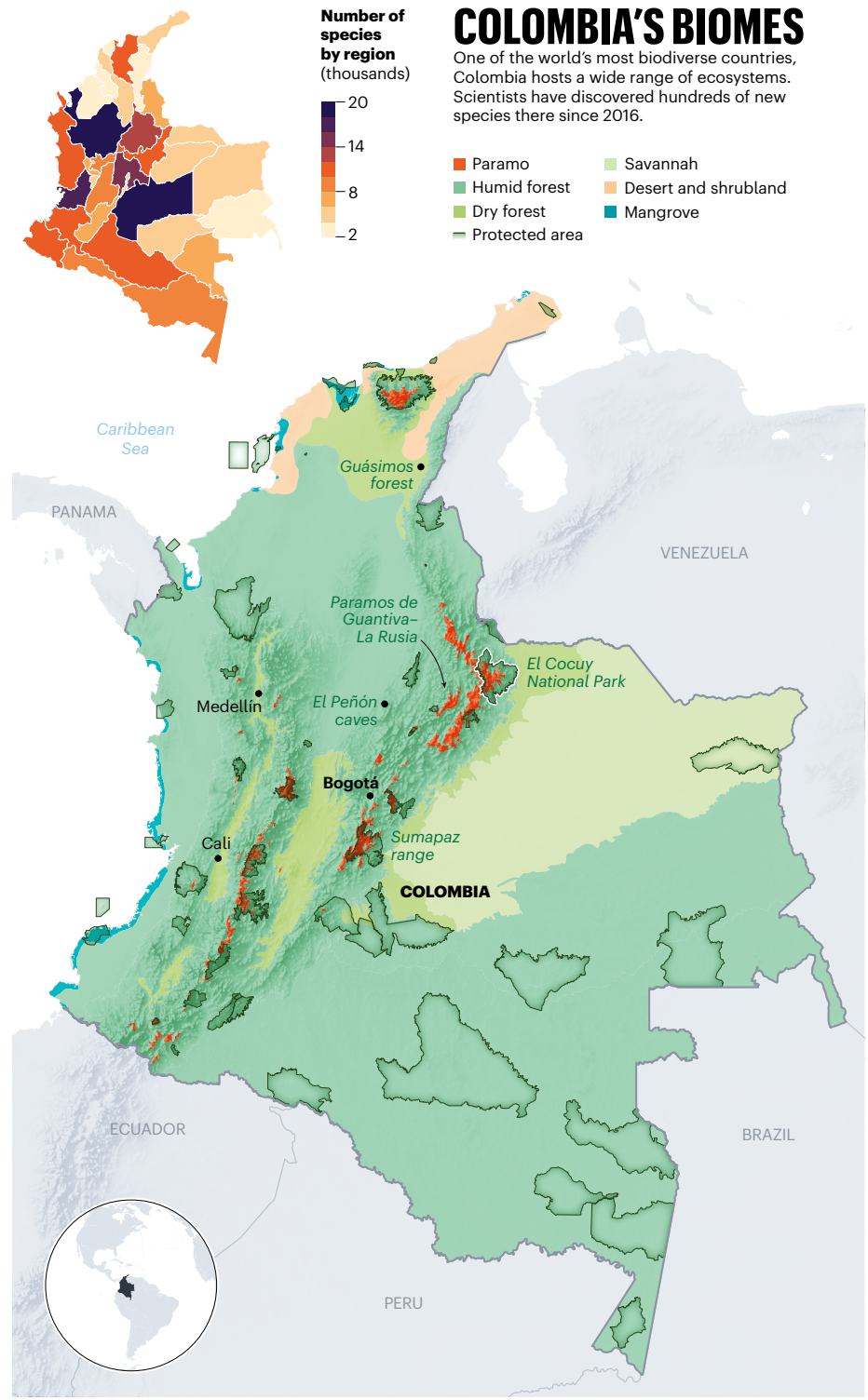
Colombia lies in the northwest corner of South America, and its megadiversity arises partly from its position at the junction of two large continental masses. It has coasts on both the Caribbean Sea and the South Pacific Ocean. It also has three Andean spines, or cordilleras,

running north–south through its centre, soaring as high as 5,000 metres, with valleys in between that plunge almost to sea level.

Climate variation across the country is huge, and the result is a vast diversity of ecosystems, from savannahs to tropical Amazon rainforest, and from alpine tundra to dry tropical forest (see 'Colombia's biomes'). Colombia hosts one of the wettest places on Earth and one of the world's highest coastal mountain formations, with two peaks exceeding 5,700 metres

## COLOMBIA'S BIOMES

One of the world's most biodiverse countries, Colombia hosts a wide range of ecosystems. Scientists have discovered hundreds of new species there since 2016.





## Feature

above sea level. Such complexity isolates species that, left to evolve on their own, become exclusive to small areas, meaning high levels of endemism. “Everything you can think of is there,” says Diazgranados.

To explore all this, then-president Manuel Santos, who propelled the country through the 2016 peace deal, seized on an existing programme known as Colombia Bio and boosted it with money and publicity. Santos saw the exploration of Colombian biodiversity not just as a scientific imperative but also as a way of nurturing national identity under the new-found peace – and a way of growing a sustainable economy.

Over the following few years, Colombia Bio received more than US\$57 million from national and international sources, according to Felipe Garcia, who directed many of the original expeditions and led the programme for the government’s research agency, then known as Colciencias. Some £10 million (US\$12.8 million) of this came from the United Kingdom, distributed through research organizations such as the Royal Botanic Gardens, Kew, and the Earlham Institute in Norwich. One priority has been to document some of the country’s most threatened ecosystems. Near the top of the list are the paramos.

### Rich collection

These unusual regions form the world’s most biodiverse high-elevation ecosystem and, across Colombia, their peaty soils, possibly helped by the water-harvesting and storage properties of the *frailejones* (plants from the genus *Espeletia*), hold 80% of the fresh water used by the country’s cities. But researchers don’t know exactly how they process and store so much water. They also want to understand the effects of so many *Espeletia* plants dying off because of rising temperatures and insect infestations. Without this knowledge, there is a risk that interventions designed to achieve sustainability will be ineffective or even damaging, scientists say.

A team of researchers from Colombia and the United Kingdom has now investigated one of these regions: the Paramos de Guantiva–La Rusia, halfway between Bogotá and the Venezuelan border. They used a radar technique originally developed to understand peaty soils in the United Kingdom to detect the millimetre-scale rise and fall in soil thickness in the paramo as it absorbs and releases rainwater. They also gathered testimonies from local people about how the paramos shape their lives and livelihoods.

One team also developed an automated way of mapping the presence of individual *frailejones* and identifying their species, using drones. The plants are tall but also slim, which makes them hard to spot from the air. The team fed the drone data into a machine-learning programme that identified the plants, whether



FELIPE VILLEGAS/COLOMBIA BIO – MINCIENCIAS/HUMBOLDT INSTITUTE

An entomologist collects a specimen on a Colombia Bio expedition in the east of the country.

they were scattered or clustered together<sup>1</sup>.

The researchers, led by Earth-observation specialist France Gerard at the UK Centre for Ecology & Hydrology in Wallingford, are tentatively concluding that maintaining plant diversity in the paramos could be less important for conserving the ecosystem than limiting compaction and erosion of the soil, for example from heavy grazing.

In an estimated 100 expeditions in the past 6 years, researchers have visited almost all of Colombia’s ecosystems. During that time, the SiB Colombia database has more than tripled the number of observations it has logged, to 21 million. This rich information has allowed scientists to develop distribution maps of species – including the ranges of 2,000 birds, says Garcia. Others are using the data to feed into policy and international efforts to monitor climate change and other phenomena.

The number of recorded species, meanwhile, has leapt from 53,000 to 81,236 since 2016; 200 are new to science, says Garcia. There are newly discovered fish, butterflies and other insects, orchids and other plants, amphibians, reptiles and a bird. It is not just expeditions that have contributed to this effort, says Copas. Colombia has also been assembling

information from environmental-impact assessments, museums and citizens who have begun recording what they see. Since 2016, the number of people registered for the nature-recording app iNaturalist in Colombia, for example, has surged nearly sevenfold.

### Useful biodiversity

In the northeast of the country, near the Venezuelan border, the heat is fierce and the dry air is noisy with crickets and birdsong. This is the Guásimos forest, in the foothills of the Serranía de Perijá mountains, a region notorious for its former violence. Now that times are more peaceful, and scientists have been working with returned local people to understand what species are here and how people can make use of them in ways that are sustainable and generate income.

Freddy Toro’s axe swings as he walks up a dry river bed with members of a local cooperative. Toro, who was forced to leave his home because of the war, but has now returned, leads the local branch of a national programme to stabilize and transform those Colombian territories most affected by the war. He bends to rummage in the dry leaves and picks up a dark, fat, blueberry-like fruit. It can be used as

a soap, he says. That one – he squints up into the shimmering canopy – can cure diarrhoea.

Toro's home is a few hours' uphill trek into the forest – a single storey of concrete blocks with a metal roof and a lean-to kitchen that reaches a furnace-like temperature as his wife fries huge pans of forest food for lunch.

Outside lie sacks filled with shiny maroon seed cases from the *orejero* tree (*Enterolobium cyclocarpum*). Inside each of the brittle, bumpy cases, reminiscent of a human ear, are seeds with a number of culinary possibilities, all now recorded by the Useful Plants and Fungi of Colombia project (see [go.nature.com/3phzxp](http://go.nature.com/3phzxp)), a major Colombia Bio effort.

As part of the project, 119 researchers have documented the country's edible and medicinal plants and fungi, aiming not only to protect them but also to help people incorporate them into their diets and make a living out of their sustainable exploitation.

Globally, there are thought to be about 7,000 plants with an edible part, such as the root or fruit. In Colombia, scientists have identified 3,800 such plants<sup>2</sup> – 50% more than previous records suggested. This number includes nearly 1,200 with edible fruits and more than 3,000 medicinal plants, of which at least 200 are endemic.

Toro's wife serves up rice cooked with the black shiny seeds of the *camajón* tree (*Sterculia apetala*) topped with an olive-green dip made from *orejero*. Later, there is a tough gingery cake made from flour ground from the seeds of the *guáimaro*, with a nutty black 'coffee' made from the same seeds, this time roasted.

*Guáimaro* (*Brosimum alicastrum*) has a long gastronomic history as a favoured plant of the Indigenous Yukpa people, and it is now forging a path that other edibles could follow. Researchers from the Useful Plants project have characterized its ecology, habitat and usefulness, both as a nutritious food and as an indicator of forest health. An international association for forest and biodiversity protection, Envol Vert, based in Bogotá and Paris, is working with local associations. The hope is to reintroduce *guáimaro*-based flour into traditional cuisine and to create a market for it in Colombia, allowing forest inhabitants to make a living while keeping the forest intact.

## Basic biology

As well as putting Colombia's biodiversity to use, researchers are drawing on new findings for important insights into genetics, evolution and more, says Mauricio Torres, a biologist at the Alexander von Humboldt Biological Resources Research Institute, headquartered in Bogotá and coordinator of the Santander Bio expeditions, part of Colombia Bio.

In one such expedition, Torres and two colleagues have been exploring a 170-kilometre-long network of caves in

Santander, a region of rivers, jungles and mountains in the eastern cordillera that had been severely affected by conflict. The caves formed over the past six million years and consist of a series of dead-end tunnels, separate from each other. Fish swam into them at different moments in history and were unable to leave, and so the system is like a set of test tubes, says Torres.

In the tunnels, scientists discovered a new species of cave-dwelling catfish<sup>3</sup>, *Trichomycterus rosablanca*, one of a group of related fishes that live in caves and surface streams. The fishes have differing degrees of adaptation to caves – for example, some have diminished eyes and others have lost them altogether. By sequencing the DNA of several individuals, the researchers demonstrated that the fish entered the tunnels at different times and, although separated from each other, acquired similar adaptations – a phenomenon known as convergent evolution<sup>4</sup>. Since moving to an underground life, some species might also have developed enhanced sensory systems that enable them to operate in the darkness.

"They have developed that over and over in this system in a short period of time," says Torres.

## "We are living in the spring, in terms of research interests in the country."

Studying what has influenced this evolutionary path "can give us a deep understanding of the mechanisms – and limitations – of adaptation", says Torres. This knowledge is especially important in a rapidly changing world, he says. "Most studies on convergence come from laboratory settings, with only a few experiments on natural systems."

These phenomena are paralleled in other subterranean species such as the Mexican cavefish *Astyanax mexicanus* and its surface-living counterparts, says Torres. The Santander discoveries will allow for detailed comparisons, he adds.

## Short on time

When the peace deal opened Colombia up, scientists were not the only groups to take advantage. People returned to tend their land and now, in some places, there are tensions between conservation and farming. In the Sumapaz paramo, government attempts to demarcate a conservation zone have led to disputes.

More-industrialized farming – of oil palm and livestock for example – is spreading. It laps at the edges of the Guásimos forest where Toro lives. Meanwhile, people are making the most of their new-found access to Colombia's

rich supplies of tropical wood, coal, oil and gold. Colombia lost 128,000 hectares of primary forest in 2022. Furthermore, illegal coca plantations are appearing in record numbers.

Meanwhile, violence persists, involving groups such as gangs of ex-combatants, drug traffickers, paramilitaries and those guerrilla groups that have not made peace deals with the government.

"Pretty much every single crisis that you can think about in the world, you have it in Colombia right now," says Diazgranados.

As a result, research trips can be stressful and require elaborate safeguards. When Diazgranados went to explore a region of El Cocuy National Park in the northeast where, as far as he knows, no scientists had ever been, the government insisted on sending in elite armed forces to the study area two weeks beforehand to prepare the way; then, with two days to go before the trip, another military cordon formed inside the first one.

He and his team of 40 Colombian and international scientists snatched 4 days of collecting before their protection ended, and they had to leave. They found 14 new plant species that Diazgranados thinks are new to science, but he left with a heavy heart: the landscape was not the untouched wilderness he had hoped to find. "The local farmers have been trashing the ecosystem," he says.

Despite these experiences, scientists do find that their work in the past seven years has seeded a sense of wonder among local people about the plants and animals they live alongside, especially when people discover that they are living in the only place in the world to host some of these species. Some residents have learned scientific skills. When Torres's phone rings these days, it is often a villager asking for help in identifying a species, or advice on how best to deal in an ecologically sensitive way with problems such as an animal attacking their crops. Sometimes they even want contacts in a government ministry to help to solve some environmental problem, or they have new range information to report for a species studied during Santander Bio.

"They developed an identity," says Torres of the communities he has met. "And once you have that identity, people are not going to just destroy their habitat – because they have connected with it."

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