# The Unsung Heroes of Climate Change

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Rainforests are the poster child for conservation. They're packed with charismatic wildlife and are essential for the health of the planet. Why wouldn't you want to try to save them? But they are not the only ecosystems playing a crucial role on Earth. For example, did you know that 450 billion tonnes of carbon is kept locked up by peat bogs? Or that the Sahara feeds the Caribbean with vital nutrients?

But because these ecosystems are less biodiverse than rainforests, they can be vulnerable to exploitation. And if we ignore their destruction, it could spell global ecological disaster.

# GRASSLANDS

*There are lots of invertebrates living in this grassy field, along with the cow (© Getty)*

We know that chopping down rainforests is like hacking away at Earth's lungs, so we need to protect trees and plant more of them. But experts say that poorly targeted tree planting can damage ancient grasslands and savannahs.

"As long as carbon stored in trees is valued above other ecosystem services, the conservation values of grassy biomes will remain threatened," says plant ecologist Dr Joseph W Veldman, from Iowa State University. "Threats can be direct in terms of financial incentives, such as carbon payments, and policies like fire suppression laws, which cause biodiverse grassy biomes to be replaced by low diversity forests or plantations. Then there are indirect threats – if forest is protected and/or an agricultural field is reforested, the burden shifts to unprotected, undervalued grassy biomes."

## Soil stash

While boreal forests – those found at high northern latitudes – are the largest carbon store on the planet, temperate grasslands get the bronze medal. The UK Countryside Survey estimates that 660 million tonnes of carbon are stashed away in our grassland soils – about one-third of all soil carbon stocks in the country.

"It's vital we protect grasslands for carbon storage," says Susan Ward, Senior Research Associate at Lancaster Environment Centre. "Conservation value is not just for the plants we see, it's also for insect pollinators and for the soil communities beneath our feet."

Free-range meat and milk come from the likes of Daisy the cow, who lives off our grasslands. But many of our insect pollinators also live in this environment. Insects pollinate 80 per cent of all plant species in Europe, which is a service worth millions.

Before Europeans settled in the 'corn belt' state of Iowa, there were 125,000km$^2$ of tallgrass prairie. Today, less than 0.1 per cent of Iowa's original grasslands remain. In the UK, over half our grasslands are 'agriculturally improved' to maximise yield. Species-rich grasslands, such as traditional hay meadows, have been decimated; less than 3 per cent of the original meadows are left.

After WWII ended, agriculture boomed with an injection of fertilisers, which reduced plant diversity and increased atmospheric nitrogen. The knock-on effect of higher nitrogen levels is a rise in grassland growth. This reduces species richness, which threatens biodiversity.

If losing the likes of the chirping cricket doesn't bother you, bear in mind that plants or beasts lurking in the long grass could help cure nasty bugs. Back in 2013, a new species of mushroom was discovered in the grasslands of Snowdonia. As some other mushroom species hold antibiotic properties, the discovery of Entoloma eryriensis put a stop to the construction of hundreds of new homes in the area.

Stopping construction locally is one thing. But how can we protect grasslands globally? "Global reforestation efforts should either constrain their 'restoration' to deforested lands or, if working in degraded grasslands and savannahs, incorporate key features of savannah-grassland restoration into their methods, such as prescribed fire," says Veldman.

Burning grasslands may sound counterintuitive, but fire is not a new phenomenon in grassy biomes and pre-dates humans by millions of years. There's even evidence of fire adaptation in some plants. The key is to tailor the fire treatment to the land. In low rainfall areas with lots of animals, fires should be spaced out over years or decades. Other areas need more frequent fires, otherwise they rapidly turn to shrublands or forests.

"Conservation agreements should recognise the important role that fire and large herbivores play in the maintenance of biodiversity and ecosystem services in many grassy biomes," says Veldman. "I hope that old-growth savannahs and grasslands can achieve the kind of public conservation and restoration support that forests have had."

**Fact file: Grasslands**

- 60 per cent of newly forested areas in the EU were formerly permanent pasture or meadows.
- 40.5 per cent of the Earth's surface is covered by grasslands.
- Calcareous (chalky) grasslands are Europe's most species-rich plant communities, with up to 80 plant species per m$^2$.
- UNESCO defines grasslands as 'land covered with herbaceous plants with less than 10 per cent tree and shrub cover'.
- 34 per cent of terrestrial carbon is stored in grasslands all around the world.

# SWAMPS, BOGS AND MANGROVES

*Lewis, in Scotland's Outer Hebrides, has a long tradition of using peat for fuel (© Alamy)*

If the word 'wetland' conjures up memories of tramping through boggy ground, you may wonder why we should care about these places. Well, aside from being great habitats for many birds, amphibians and beneficial insects, wetlands could help us keep a lid on global warming.

Take the case of peat bogs. Formed over millions of years from moss, wood and dead plants, these swampy habitats can be vast – one the size of England was discovered in the Congo in 2014.

As decomposers can't survive in these wet, oxygen-poor conditions, organic matter doesn't get broken down. This means the carbon that was in the plants becomes trapped in the peat. Each square metre of peat can be packed with hundreds of kilograms of undecomposed organic matter. Research shows that about half of the peat in the northern hemisphere is made up of carbon, while up to 450 billion tonnes of the element is sequestered in peat bogs around the world – that's like stashing away 65 years' worth of our current carbon emissions from burning fossil fuels.

When peat bogs dry out, carbon is released into the atmosphere. Over the next few centuries, 40 per cent of carbon could be lost from shallow peat bogs and as much as 86 per cent from deep bogs.

Global warming won't just dry out peat bogs, it'll also cause frozen ones to thaw. Beneath the Arctic tundra lie more than 1,000 billion tonnes of carbon – double the human emissions since the Industrial Revolution. Man-made climate change has forced Arctic air temperatures to rise twice as fast as elsewhere around the planet, while permafrost temperatures have soared by 5.5°C since the 1980s.

While there have been fears that thawing permafrost could cause a sudden big ‘belch’ of methane and carbon dioxide to be released, recent research by the US Geological Survey found that it’s more likely to be a gradual process. But the impact will be immense.

A so-called ‘climate feedback loop’ is what’s really causing scientists to frown. If the permafrost warms up too much, some microbes will be able to decompose organic matter, releasing more greenhouse gases, warming the planet further and heating up the permafrost.

# Water hero

Alarmed by a possible future of ‘runaway global warming’, some engineers are suggesting radical geoengineering solutions. But this could be too little too late. Permafrost is already thawing and what we’ve seen so far may just be the tip of the peat bog.

In warmer climates, mangroves are the unsung heroes of coastal habitats, storing up to four times more carbon than any other tropical forest. The secret lies in the mangrove’s dense bundle of roots that anchors it in the water. Tidal water slows down as it hits the roots, reducing coastal erosion but also dumping organic material. Microbes don’t decompose this material due to low-oxygen levels. Deforestation of these precious trees generates enormous amounts of carbon a year. Mangroves have a whole host of other benefits too. Not only has research shown that they protect sensitive corals from the threat of rising temperatures and ocean acidification, they’ve also been found to filter heavy metals and are a potential source for antibiotics.

Over the last 50 years, mangroves have been reduced by up to a half by deforestation. Sadly, protecting the habitat of the pygmy sloth or the mangrove cuckoo doesn’t feature too highly on Señor’s checklist when he can pull in the pesos by developing prime coastal real estate – while a wily government minister also lines their pockets.

If the little sloth doesn’t tug at their heartstrings, hopefully the threat of coastal erosion and the loss of natural fish nurseries, and a pat on the back for hitting carbon emission targets, will persuade ministerial minds to give the thumbs down to new developments.

By understanding facts about ecosystems, such as drained wetlands give off the same amount of greenhouse gases as industry, some governments already see the benefits of protecting them. Over the last few decades, Sweden has built wetlands on land traditionally used for farming. Wetlands prevent surplus nutrients from leaching into lakes and oceans, protecting endangered frog and bird species. A study by Halmstad University shows that wetlands have been partly responsible for the little grebe and the little ringed plover being taken off the IUCN Red List.

The long and short of it is that wetlands are great carbon sinks, wonderful filters and a treasure trove for medicines – as well as being vital for native wildlife and local communities.

**Fact file: Wetlands**

- 50 per cent of wetlands have disappeared in the last century.
- 67 per cent of European wetlands that existed 100 years ago have been lost.
- 6 per cent of Earth's land area is wetlands.
- Since the 1950s, 84 per cent of peat soils have been lost in the UK due to drainage and extraction.
- A quarter of the most important wetlands in Europe are threatened by groundwater overexploitation.

# DESERTS

*Just 166mm of precipitation falls on Antarctica each year, which means it's classified as a desert (© Alamy)*

Empty. Endless. Lifeless. That's what springs to mind when you hear the word 'desert'. But there's more to deserts than meets the eye. And not all of them are hot, dry and dusty – Antarctica is a desert as it experiences less than 200mm of rainfall every year.

Climate change is playing havoc with Antarctica. Rising temperatures are creating wetter conditions, altering the soil and changing the carbon dioxide levels.

"A small increase in temperature can tip the ecosystem from frozen to melting, turning patches of desert into a wetland," says Prof Ross Virginia, Director of the Dickey Center's Institute of Arctic Studies at Dartmouth College in the US. "That makes the soil a very different kind of habitat for the organisms living there, and it can change the cycling of carbon and the release of carbon dioxide."

# Desert deposit

Just like grasslands and wetlands, deserts are also great carbon stores. The Kalahari Desert in Botswana is full of drought-resistant cyanobacteria that fix atmospheric carbon dioxide. And recent research suggests that vast, hidden aquifers could be stashing carbon.

For years, scientists were baffled by the so-called ‘missing carbon sink’. About 40 per cent of carbon emissions remain in the atmosphere, around 30 per cent get soaked up by the oceans and almost all of the remainder is absorbed by plants. But a tiny bit is leftover – so where does it go?

Researchers from the Chinese Academy of Sciences recently discovered a huge lake beneath China’s Tarim basin that holds 10 times more water than the North American Great Lakes.

“Our definition of ‘desert’ may have to change,” explains biogeochemist Yan Li from the Chinese Academy of Sciences. “Atmospheric carbon is being absorbed by crops, released into the soil and transported underground in groundwater. These saline aquifers under the desert are covered by a thick layer of sand and will never return to the atmosphere, probably becoming carbonate rocks or salt mines. It’s basically a one-way trip. The nice side of this story is that this carbon sink is enhanced by human activities – irrigated farming speeds up carbon dioxide absorption.”

While sandstorms were a pain in the backside for Lawrence of Arabia, desert dust is vital for many ecosystems. The AERONET project is a series of ground-based monitoring stations around the globe, which measure atmospheric aerosols. When dust is blown from the Sahara over the Iberian Peninsula, researchers have found that less radiation reaches Earth’s surface than normal. Hence, desert dust cools the planet.

Saharan dust can be blown even further afield than Spain. In fact, it’s known to travel across the Atlantic to the Caribbean. Once there, it supports plants with nutrients when levels are low in the ocean. Meanwhile, dust from deserts in Mongolia and northern China is blown as far away as the Pacific Ocean, where phytoplankton survive on the iron-rich dust.

“If there are changes in desert size or in the way people use land, there could be a greater source of dust to the Pacific,” says Chris Hayes, from MIT’s Department of Earth, Atmospheric and Planetary Sciences (EAPS). “It’s difficult to predict, but larger deserts could produce a greater source of dust to the ocean, which could potentially increase the growth of certain phytoplankton groups.”

The carbon fixed by phytoplankton is absorbed by larger organisms feeding on the algae. Working its way up the food chain, carbon gets ‘packaged’ into larger particles, including faecal pellets, which sink down into the deep ocean. So phytoplankton growth is important for regulating Earth’s climate.

“By increasing phytoplankton growth, dust could have a positive impact on the climate by drawing down atmospheric carbon dioxide concentrations,” explains Hayes.

All this goes to show it’s a mirage to think that deserts are empty vast plains or freezing wastelands that are only good for a Top Gear special. Deserts may appear lifeless, but they are in fact vital for life.

**Fact file: Deserts**

- One-third of Earth's surface is desert*
- 11 per cent is the increase in desert foliage over the last two decades. This is due to soaring levels of carbon dioxide.
- 20 per cent of deserts are covered in sand.
- Antarctica is the world's largest desert. The only plants that grow there are mosses and algae.
- China is building a 4,500km-long 'Great Green Wall' made up of 100 billion trees to try to hold back the Gobi Desert.

*based on the definition of a desert being a region with less rainfall in a year than it gives up through evaporation.