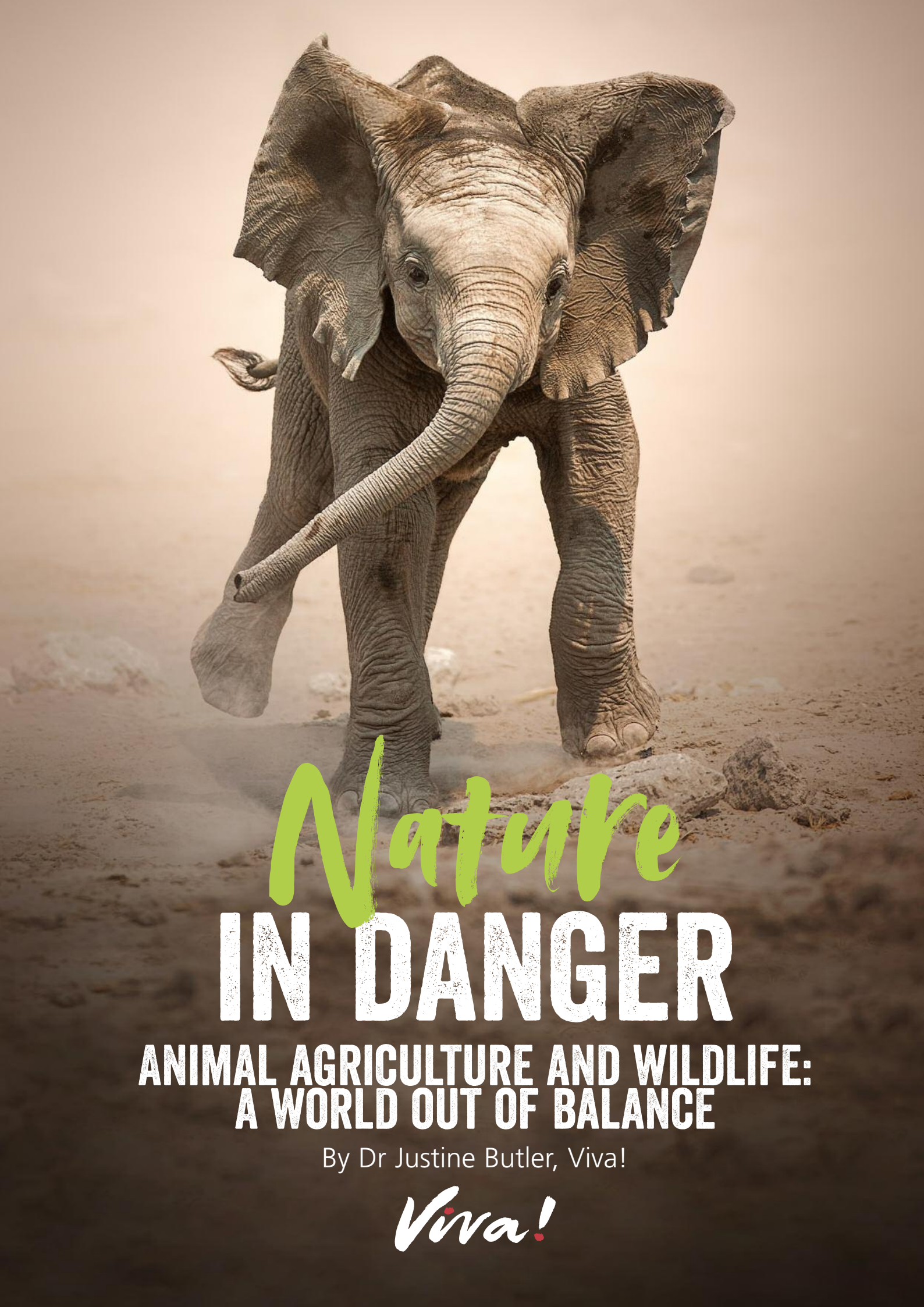

Nature IN DANGER

ANIMAL AGRICULTURE AND WILDLIFE: A WORLD OUT OF BALANCE

By Dr Justine Butler, Viva!

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Executive summary

Biodiversity comprises the amazing variety of all life on Earth, from tiny microorganisms to large land, marine and aquatic species of both plant and animal. Of the estimated 8.7 million different species on the planet, only 14 per cent of those that exist on land, and nine per cent that inhabit the oceans, have been classified. Many will become extinct before they can even be identified.

A rich biodiversity is critically important for all life on Earth; complex ecosystems produce oxygen, filter water, recycle nutrients, generate soil and pollinate seeds. The air we breathe, water we drink, food we eat and medicines we depend on, all rely heavily on biodiversity. Bats, birds, butterflies, bees and other pollinators support over three-quarters of global food crops, including coffee, cocoa and almonds.

We are experiencing the world's sixth mass extinction. Unlike previous events that were caused by asteroids, volcanic eruptions and natural climate shifts, this crisis is caused by human activity. One million plant and animal species are threatened with extinction and industrial farming and fishing are the major drivers of the crisis. From the huge African elephant down to tiny dung beetles and microscopic phytoplankton, we are losing species at 1,000 times the natural rate.

Climate change is directly impacting nearly one in five of all threatened species but overexploitation and agricultural activity are the most prevalent threats, and the expansion of agriculture alone is threatening 62 per cent of endangered species. Magnificent mammals, such as Africa's cheetahs and mountain gorillas, the UK's hedgehogs and water voles and the hooded seals of the cold waters of the North Atlantic and Arctic Oceans are just a handful/a mere few of those affected by livestock farming and aquaculture.

The human appetite for animal protein comes at a high price. Meat, fish, eggs and dairy demand 83 per cent of the world's farmland, contribute over 50 per cent of the greenhouse gas emissions from food production but provide only 37 per cent of the protein we eat and just 18 per cent of our calories. Nearly three-quarters of the world's freshwater resources are used for livestock and crops (including animal feed), often at the expense of tropical forests, wetlands, grasslands and the plants and animals that inhabit them.

Around 40 per cent of insects are in decline – described by biologists as an "insect apocalypse", moths, butterflies, bees and dung beetles are particularly threatened, while small animals that live below ground

are under threat too; over a third of fields in England are seriously deficient in earthworms.

Lemurs in Madagascar help disperse the seeds of big trees, which play an important role in carbon storage but are under threat from slash-and-burn agriculture, livestock grazing, hunting, logging and mining. Africa's central rainforest elephants are facing similar dangers as their number has been decimated from around a million in the early 19th century to around 100,000 today.

Sumatran elephants are critically endangered largely due to oil palm plantations destroying their territory. Palm kernel meal, a lucrative by-product of palm oil production, is used as animal feed. More than a tenth of the world's palm kernel meal is fed to British livestock and companion animals and little, if any, comes from sustainable sources. Eat a steak and you kill a lemur in Madagascar; eat a chicken and you kill an Amazonian parrot; eat a ham sandwich and you kill a Sumatran elephant…

The world's glaciers host entire ecosystems of tiny insects, worms, fungi, algae, bacteria and microscopic water bears – and almost all are melting. Scientists are racing against time to discover and record this huge array of life before they disappear forever.

Primates are our closest biological relatives and play an essential role in tropical biodiversity – contributing to forest regeneration and ecosystem health – but around 60 per cent are threatened with extinction because of deforestation, habitat loss, agricultural expansion, cattle-ranching, overexploitation, hunting for bushmeat and illegal trade as pets or 'medicinal' body parts, in addition to climate change.

The expanding production of soya beans, palm oil and beef, scientists say, is seriously impacting biodiversity and primate populations. A list of 25 of the most endangered primates includes the Western chimpanzee and the recently discovered Skywalker hoolock gibbon. As a result of poaching, loss of habitat to agriculture and infectious diseases, great ape numbers have collapsed, with less than 1,200 mountain gorillas remaining.

Trees are a vital carbon sink and store around 40 per cent of all land carbon while producing up to 20 per cent of the world's oxygen; mostly from rainforests. The Amazon is biologically the richest region on Earth and is one of the last refuges for numerous species, including jaguars and pink river dolphins. It is home to sloths, black spider monkeys and poison dart frogs, and perhaps a million more undiscovered species. Agriculture is the main driver of global deforestation in order to provide land for grazing and animal-feed crops.

Grasslands and savannahs are also being destroyed for meat production and a typical example is the African savannah; home to a huge variety of mammals, reptiles, amphibians and birds. Roaming elephants and buffalo, grasshoppers and beetles, ants and termites

constitute an extraordinarily complex and diverse ecosystem that has evolved over thousands of years but which is now under threat, with many native animals becoming endangered.

Less than 100 years ago, some 10 million elephants roamed the African continent but decades of poaching, conflict and habitat loss have devastated them with only around 350,000 remaining.

The Monarch butterfly is native to the US, between four and 10 million once inhabited the California coasts – there are now fewer than 30,000. They are victims of commercially grown corn and soya, most of which goes to animal feed. It is genetically modified to be resistant to herbicides, which have obliterated the important milkweed plant that the butterfly larvae rely on.

We have an extinction crisis but also a broader biodiversity 'biome crisis', where the ecological function of different biomes are at risk; again largely due to land conversion. Some of these biomes are the most species-rich ecosystems on Earth.

The climate crisis has diverted attention away from other threats, including the devastating impact that the consumption of fish and shellfish is having on marine biodiversity. Over a third of wild fish are now overfished, compared to 10 per cent in 1974. Larger fish are being squeezed from both ends; under threat from overfishing and under pressure as numbers at the bottom of the food chain decrease due to climate change. Without significant changes, more than half of the world's marine species may face extinction by the end of this century.

Coral reefs support over a quarter of all marine life but around half of all shallow water corals have already been lost due to overfishing and rising sea temperatures and up to 90 per cent could be gone by 2050. As atmospheric carbon dioxide dissolves in the ocean, it increases acidity and organisms whose shells are made from calcium carbonate have to work hard at strengthening their shells to survive.

Seagrasses store carbon but have been disappearing at a rate of 110 square kilometres a year since 1980. Some microscopic plant-like phytoplankton populations are falling by one per cent a year. They not only store carbon but also provide half of all the Earth's oxygen.

The UK is one of the most nature-depleted countries in the world with around one in six native species threatened with extinction. A quarter of UK mammals and nearly half of all birds are at risk – hedgehogs, hares and bats, as well as numerous birds including the willow tit and the turtle dove; and insects such as the high brown fritillary butterfly, are all living under threat. The 'usual culprits' are responsible – intensification of farming, use of pesticides and fertilisers, higher stocking densities for sheep and cattle, greater mechanisation and the loss of field margins, hedgerows, wooded areas and farm ponds.

Insects are moving north at a rate of two kilometres a year in the UK due to increased temperatures from climate change, while in North America, the geographic ranges of half the plants and animals have shifted for similar reasons. Eleven of the 47 mammals native to Britain are on the brink of extinction, while a further five species are classified as near threatened.

Vast ancient woodlands once covered most of Britain but have been reduced to just 2.4 per cent of its land area. Building and infrastructure projects are to blame but an increasing threat comes from ammonia released from intensive pig and poultry farms. Agriculture accounts for 88 per cent of UK ammonia emissions, with most coming from livestock manure. This type of nitrogen air pollution strips trees of their protective lichens and causes a fertiliser effect allowing grasses to out-compete more delicate woodland flowers.

Two centuries of sheep farming, particularly on upland soils, has reduced a rich natural resource to a state of desolation, referred to by one ecologist as a "wet desert". The choice is stark – if all UK cropland was used to grow plants for people rather than feeding animals, enough protein and calories could be produced for the entire population and most grazing land could be restored to native forest, equal to offsetting nine years' worth of UK greenhouse gases emissions.

Three-quarters of the world's food is generated from just 12 plant and five animal species and the Irish potato blight of the mid-1800s illustrates just how precarious this is. The banana is a typical example, with 99 per cent of exports to developed countries being of just one variety – the Cavendish. There are over 500 other varieties, with different coloured skins and pulp and with a range of textures and flavours. Diversity is insurance.

The imbalance of life on Earth is staggering. There are, for instance, 24 billion chickens in the world – more than three birds for every person at any one time. The global distribution of mammals by weight is equally

bizarre – 60 per cent are livestock, 36 per cent are humans and only four per cent are wild mammals.

Such massive livestock populations have profound consequences for biodiversity, including their contribution to climate change, deforestation, change of land use, overgrazing, degradation of grasslands and desertification. Crops used to produce animal feed such as soya, maize and oil palm, means that all meat-eaters globally are contributing to this destruction.

Climate change – also driven by the livestock industry – is taking its toll on global biodiversity. Animal agriculture produces around a fifth of human-induced greenhouse gases emissions, more than all the world's transport combined. The solution is to go vegan.

In essence, the primary cause of biodiversity loss is the destruction of habitat due to human-related activities, with animal agriculture at the heart of the problem. Over the next few decades, climate change is expected to push even more species over the brink. We are already seeing one of its effects with wildfires, for example, blazing not only in Australia and California but also in the Arctic. Encroaching into wildlife habitats is also increasing the risk of zoonotic 'spillover' diseases such as Covid-19, Ebola and HIV/AIDS and poses a pandemic threat. We seem to take it for granted that nature will absorb all the abuse we throw at it and somehow still cope. It can't and it isn't – it is literally dying around us.

We must change the way we treat animals and the environment and what we eat. We have to make the connection between animal agriculture, environmental destruction and disease. We are destroying nature to feed our hunger for meat and fish and that has to stop. We must protect ecosystems and prioritise the safety and freedom of wild animals, leaving them to live their lives free from human interference. If we don't take urgent and far-reaching action now, eating animals will be the death of us.

Introduction

One million animal and plant species are threatened with extinction, many within decades and more than ever before in human history. This was the stark conclusion reached in 2019 by the United Nations' Intergovernmental Panel on Biodiversity and Ecosystem Services (IPBES), an independent intergovernmental body comprising more than 130 governments.

Many scientists are now saying that the most serious aspect of the environmental crisis is the loss of biodiversity – the other living things with which we share Earth. The huge losses, they describe as 'biological annihilation', represent a crisis that could surpass climate change.

Mass extinctions are when the Earth loses more than three-quarters of its species in a geologically short interval. This has happened five times over the past 540 million years or so, but we are now destroying animals, plants and fungi at an accelerating rate, initiating a mass extinction unparalleled since the last event 66 million years ago. That one was probably caused by the impact of a massive comet or asteroid. Unlike previous mass extinction events, caused by asteroid strikes, volcanic eruptions and natural climate shifts, the current crisis is caused by human activity.

As the world's population has grown, animal agriculture has expanded to meet the rising demand for meat, fish, eggs and dairy. Forests are being destroyed to make way for animal grazing and feed crops. The oceans are being decimated by huge industrial trawlers that tear up the ocean floor and destroy everything in their path. Drylands are expanding and land once fertile is becoming arid and unable to support life. Ecosystems that have evolved over thousands of years are breaking down. As animal agriculture expands, the natural world is shrinking.

Billions of mammals, birds, reptiles and amphibians have been lost all over the planet, leading some scientists to say the sixth mass extinction has already progressed further than previously thought. One million species of animals and plants are at risk of extinction – what most people don't realise is that we humans are included too!

IPBES Chair, Sir Robert Watson, said: "The health of ecosystems on which we and all other species depend is deteriorating more rapidly than ever. We are eroding the very foundations of our economies, livelihoods, food security, health and quality of life worldwide." But there is still hope, Watson said: "The [IPBES] Report also tells us that it is not too late to make a difference, but only if we start now at every level from local to global."

What is biodiversity?

The term biodiversity was first used in 1985, as a shorter way of saying biological diversity. It refers to all land, marine and aquatic species of plant and animal, the genetic diversity between them and the ecosystems they inhabit. It also includes microorganisms such as bacteria and fungi. In other words, biodiversity is the amazing variety of all life on Earth.

Sea turtle and coral reef

The living layer of life around the Earth, on land and in the oceans, is called the biosphere. Our air, water, soil, oceans and climate all depend on the complex, dynamic interactions that occur between the billions of plants, animals and microorganisms that inhabit the biosphere.

Knowing how many species inhabit Earth is among the most basic, yet elusive, questions in science and it's been suggested that scientists have a better understanding of how many stars there are in the galaxy than how many species there are on Earth.

In 2010, Lord Robert M. May, then Professor of Zoology at the University of Oxford, said if aliens visited Earth, he thought their first question would be: "How many distinct life forms – species – does your planet have?" Embarrassingly, he said, our best-guess answer would be in the range of five to 10 million (May, 2010).

Since then, the most widely-accepted estimate puts the figure at 8.7 million, of which 2.2 million are marine species (Mora *et al.*, 2011). This estimate includes all five known kingdoms of eukaryotes – living organisms with structured cells – and predicts 7.8 million species of animals (including insects), 298,000 species of plants, 611,000 species of fungi, 36,400 species of single-celled organisms (or protozoa) and 27,500 species of chromists which include brown algae, diatoms and water moulds. It does not include bacteria and viruses, which are highly numerous.

However, only 14 per cent of land-based species and nine per cent of those living in the ocean have been classified – the vast majority have yet to be identified.

The fungal kingdom is less well studied than the plant kingdom and little is known of its true biodiversity, which has been estimated at 2.2 million to five million species (Blackwell, 2011). Of these, only 148,000 have been described (Cheek *et al.*, 2020).

The team behind the 8.7 million figure warns that given current extinction rates, many species will become extinct before they can be studied.

Human (or anthropogenic) impacts on the environment have become increasingly damaging and we have now reached a point where life on Earth, as we know it, is threatened with the type of destruction usually associated with science fiction disaster films!

Why does it matter?

An urban fox

For many people living in towns and cities, apart from the odd bird or urban fox, wildlife is generally only seen in TV documentaries. Some people may have heard about the plight of tigers or orangutans, but the threat of extinction extends to one million animal and plant species around the world.

"Biodiversity and nature's contributions to people sound, to many people, academic and far removed from our daily lives" says IPBES Chair, Sir Robert Watson. He says: "Nothing could be further from the truth – they are the bedrock of our food, clean water and energy. They are at the heart not only of our survival, but of our cultures, identities and enjoyment of life" (IPBES, 2018). David Macdonald, Professor of Wildlife Conservation at the University of Oxford says: "Without biodiversity, there is no future for humanity".

A rich biodiversity is critically important for all life on Earth for many reasons. The huge population declines we are seeing now, scientists warn, will have negative cascading consequences on ecosystem functioning and services vital to sustaining human civilisation (Ceballos *et al*., 2017).

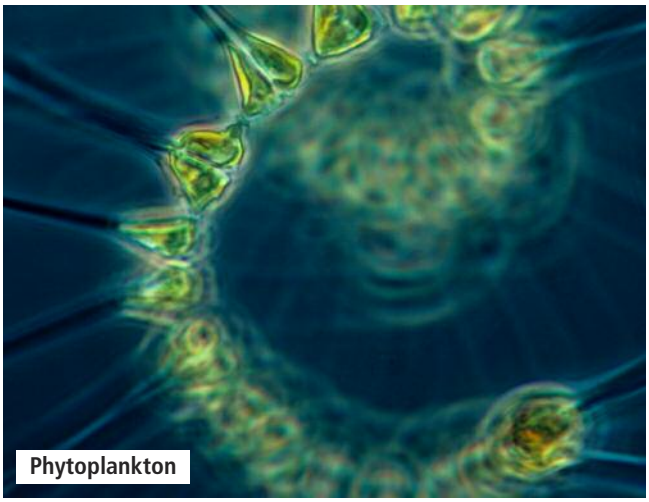
Natures' complex ecosystems provide a wide range of services including: oxygen production, water filtration, nutrient recycling, soil generation, pollination and seed dispersal. In fact, nature regulates many processes that we don't even realise are the basis of our economies, lives and well-being, provides protection from environmental hazards and regulates the climate. The air we breathe, water we drink, food we eat and medicines we depend on, all rely heavily on biodiversity. We simply could not survive without the wide variety of animals, plants, fungi and microorganisms with which we share the Earth – and we need them much more than they need us!

Phytoplankton and rainforests

Phytoplankton are single-celled plants that drift near the ocean's surface, living off carbon dioxide and sunshine. The name phytoplankton comes from the Greek words *phyton* meaning plant and *planktos* meaning to wander or drift. These microscopic species form the basis of the entire marine food chain providing food for krill; small, shrimp-like crustaceans that are the main staple food of hundreds of different animals including fish, whales, seals, penguins, squid and many others. Krill are the basis of the food web in the Southern Ocean around Antarctica and most marine species depend on krill for their survival.

The carbon cycle

Phytoplankton have an important role storing carbon and are responsible for most of the transfer of carbon dioxide



Phytoplankton

from the atmosphere to the ocean. They produce their energy through photosynthesis, like other plants, taking in carbon dioxide and releasing oxygen. They account for about half of the photosynthesis on the planet, despite amounting to only about one per cent of the global plant biomass. They are one of the world's most important producers of oxygen. But phytoplankton populations in the oceans have declined substantially over the past century because of rising sea temperatures and acidification, caused by carbon dioxide in the atmosphere dissolving in the sea.

Rainforests also produce some of the oxygen we breathe but an even more significant value lies in their rich biodiversity, their vast ability to store carbon and the way they influence the local and global climate – we are only just discovering the significance of some of these roles.

Pollinators

Bats, birds, butterflies, bees and other small insects are very important pollinators. More than three-quarters of global food crops, including fruits and vegetables and some of the most important cash crops, such as coffee, cocoa and almonds, rely on animal pollination and would not survive without it. The decline in pollinating insects could have dire consequences for ecosystems and food security. If you want variety in your food cupboards and on your plate, we need to preserve biodiversity in nature.

Whether you are looking at coral reefs bleaching, forests becoming savannahs or ice sheets melting, disrupting ecosystems that have developed naturally, over thousands or even millions of years, is likely to have devastating consequences. How dependent one part of a complex ecosystem is on another may not be apparent until it is lost. Think of biodiversity like a knitted jumper – pulling out a loose thread may not cause a serious problem but it may unravel the entire jumper.

Only 14% of species on Earth and 9% in the ocean have been classified
Many species will become extinct before they can be identified

Source: Mora *et al.*, 2011.

Writing in *The Guardian*, Professor of Environmental Sciences Garry Peterson, from the Stockholm Resilience Centre in Sweden, said: "We're surprised at the rate of change in the Earth system. So much is happening at the same time and at a faster speed than we would have thought 20 years ago. That's a real concern. We're heading ever faster towards the edge of a cliff" (Watts, 2019). Is this a risk we really want taken with the future of the planet?

Pandemic threat

The elephant, or perhaps the bat, in the room is Covid-19. The expansion of animal agriculture and the destruction of wild habitats makes it more likely that infectious diseases in wildlife will transfer to humans. If we keep invading and decimating wild landscapes, killing wild animals or capturing them and taking them to markets, we will inevitably shake viruses loose from their natural hosts.

Bees and butterflies – pollinators

The coronavirus that caused the Covid-19 pandemic is thought to have jumped to humans from bats, possibly via a pangolin – the world's most trafficked animal, overexploited for both their scales and meat. Of the nine different pangolin species listed by the IUCN, three are critically endangered, four are endangered and the remaining two are vulnerable (IUCN, 2022).

However, 10 years ago, in a remote cave in Yunnan province in China, virologists found horseshoe bats harbouring a virus very similar to SARS-CoV-2 (the virus that causes Covid-19). In the laboratory they found the virus was able to infect human cells (Ge *et al*., 2013) and in 2016, researchers reported that it could replicate in human airway cells. They described it as being "poised for human emergence" (Menachery *et al*., 2016). A failure to act on these warnings could mean an opportunity to protect human health was missed.

> "Pandemic prevention governance has mostly focused on outbreak surveillance, containment, and response, rather than on avoiding zoonotic spillovers."
>
> Gallo-Cajiao *et al*., 2021.

Diseases that jump from animals to humans are called "zoonotic diseases". Other notable ones include Ebola, SARS and MERS, all caused by viruses that spilled over from bats to chimpanzees (hunted for bushmeat), civet cats (in wet markets) and camels (used for meat and racing), respectively. The HIV virus that causes acquired immune deficiency syndrome (AIDS) is thought to have jumped to humans from primates (chimpanzees and sooty mangabey monkeys) hunted for bushmeat. And of course, avian influenza viruses, of varying degrees of pathogenicity, are now present in pig and poultry farms across the world.

One way to take control is for large numbers of people to stop eating meat, stop wild markets and stop factory farming – thus taking away the opportunity for new viruses to mutate and jump species.

We must change the way we view animals, the environment and our diets. We must stop eating animals. It is time to finally make the connection between animal agriculture, environmental destruction and disease outbreak. We must stop tearing down forests to make way for animal farming or to grow animal feed. We must protect ecosystems and prioritise the safety and freedom of wild animals, leaving them to live their lives away from human interference. If we don't take urgent and far-reaching action now, eating animals will be the death of us.

Assessing the problem

"Biodiversity – the diversity within species, between species and of ecosystems – is declining faster than at any time in human history."

IPBES, 2019.

The IPBES report

In 2019, the United Nations' Intergovernmental Panel for Biodiversity and Ecosystem Services (IPBES) report made headline news around the world with its figure of one million species at risk of extinction. The report found that one million animal and plant species are now threatened with extinction, many within decades, more than ever before in human history (IPBES, 2019).

Rainforest being removed

The IPBES Global Assessment Report on Biodiversity and Ecosystem Services is the most comprehensive assessment ever completed. Compiled by 145 expert authors from 50 countries over three years, with inputs from another 310 contributing authors, it assessed changes over the past five decades and offered a range of possible scenarios for the coming decades.

The abundance of native species in most major land-based habitats, the report says, has fallen by at least 20 per cent, mostly since 1900 (IPBES, 2019). The report identified industrial farming and fishing as the major drivers of the crisis.

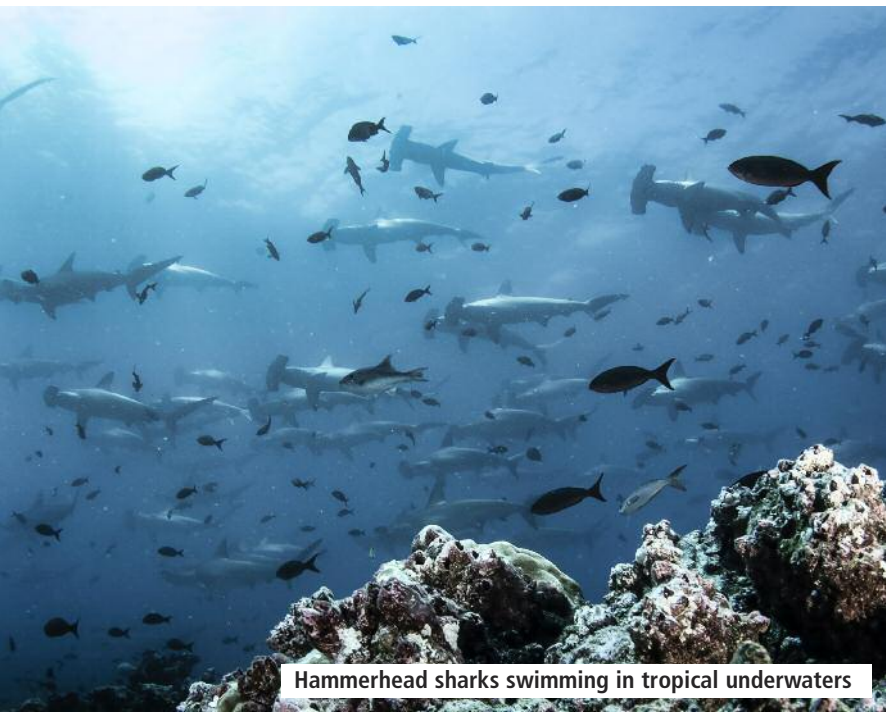
Extinction is a natural phenomenon occurring at a normal rate of about one to five species per year. Scientists estimate we're now losing species at up to 1,000 times that background rate, with literally dozens of species going extinct every day. Professor Sandra Díaz, who co-chaired the IPBES assessment, said: "Biodiversity and nature's contributions to people are our common heritage and humanity's most important life-supporting 'safety net'. But our safety net is stretched almost to breaking point" (IPBES, 2019).

> One million plant and animal species are threatened with extinction
>
> Source: IPBES, 2019.

The IPBES report says that in addition to the million species at risk of extinction, the biomass (weight) of wild mammals has fallen by 82 per cent and the world's natural ecosystems have lost about half the area they previously occupied – all largely because of human activities such as cutting down forests and converting land into fields for animal agriculture.

This report has put the world on notice, according to the Director of the United Nations' Educational, Scientific and Cultural Organisation (UNESCO), General Audrey Azoulay, who said: "Following the adoption of this historic report, no one will be able to claim that they did not know. We can no longer continue to destroy the diversity of life. This is our responsibility towards future generations" (UN News, 2019).

Another biodiversity report that made the headlines comes from the conservation organisation WWF and the Zoological Society of London, among other groups. Every year, they produce the Living Planet Index, which has amassed data for 27,695 populations of 4,806



Hammerhead sharks swimming in tropical underwaters

vertebrate species. Their 2020 report stated that population sizes of birds, mammals, fish, amphibians and reptiles declined on average, by 68 per cent between 1970 and 2016. They say: "The findings are clear: Our relationship with nature is broken" (WWF, 2020).

The IUCN Red List

The International Union for Conservation of Nature's (IUCN) Red List of Threatened Species is a useful indicator of the health of the world's biodiversity – a barometer of life.

Established in 1964, the IUCN Red List has evolved to become the world's most comprehensive information source on the global conservation status of animal, fungi and plant species. Species are assessed and then classified as: extinct, extinct in the wild, critically endangered, endangered, vulnerable, near threatened, least concern, data deficient or not evaluated (IUCN, 2022).

The IUCN Red List reveals that from the treetops to the ocean floor, wildlife destruction and loss of habitat is driving many species towards extinction with nearly a third of all species assessed living under threat. As of early 2022, more than 142,000 species had been assessed and of those, more than 40,000 are threatened with extinction (IUCN, 2022).

The IUCN Red List was key in informing the IPBES report. They extrapolated the IUCN's previous 25 per cent threatened rate to the rest of the world's species, using a lower rate for the 5.5 million or so species of insect. However, according to the latest IUCN updated figures given above, 28 per cent of species assessed are now threatened (IUCN, 2022).

Writing in the *Proceedings of the National Academy of Sciences*, scientists looking at terrestrial vertebrates said that the rate of population loss is extremely high. In their sample, which included nearly half of all known vertebrate species, a third were found to be decreasing in population size and range. Of the 177 mammal species they looked at, all had lost 30 per cent or more of their geographic ranges and more than 40 per cent had experienced severe population declines. Using uncharacteristically strong language for a scientific publication, they describe this as "biological annihilation" to highlight the magnitude of the Earth's ongoing sixth major mass extinction (Ceballos *et al*., 2017).

The assault on wildlife does not distinguish between species. From the huge African elephant down to tiny dung beetles and microscopic, single-celled phytoplankton that live in the oceans, all are living under threat. Primates, birds, bats, bees and butterflies as well as forests, rangelands, mangroves, seagrass meadows, coral reefs and wetlands – all are rapidly declining. This loss of biodiversity poses as serious and urgent a threat to humans as climate change.

Animals under threat

Birds 13%
Reptiles 21%
Mammals 26%
Crustaceans 28%
Reef-forming corals 33%
Conifers 34%
Sharks and rays 37%
Amphibians (frogs/toads/newts) 41%
Cycads (ancient palm-like plants) 63%

Source: IUCN, 2022.

The link with livestock

"You eat a steak, you kill a lemur in Madagascar.
You eat a chicken, you kill an Amazonian parrot."

Gidon Eshel, Research Professor of Environmental Physics at Bard College in New York.

As the global human population grows, more and more land, water, energy and other precious resources are being taken to meet the ever-growing demand for cheap meat, fish, eggs and dairy. Species-rich habitats are being converted for grazing and animal feed crops to meet this relentless and insatiable demand. There is a tendency for reports about threats to biodiversity to focus on climate change as the main cause, but most the world's threatened species are being put at risk by agriculture, land conversion and overharvesting.

African cheetah

Writing in the journal *Nature*, a team from the University of Queensland, the Wildlife Conservation Society and the IUCN assessed around 9,000 near-threatened or threatened species on the IUCN's Red List against 11 threats: overexploitation, agricultural activity, urban development, invasion and disease, pollution, ecosystem modification, climate change, human disturbance, transport and energy production. They found that overexploitation and agricultural activity were by far the most prevalent threats and said the expansion of agriculture alone is threatening 62 per cent of threatened and near-threatened species (Maxwell *et al.*, 2016).

This study found that Africa's cheetah, South America's huemul deer and Asia's hairy-nosed otter, for example, were among those affected by livestock farming and aquaculture. The Fresno kangaroo rat and the African wild dog, they say, are under threat from land use changes associated with the production of food, animal feed and biofuels. Climate change – leading to storms, flooding, extreme temperatures, drought and sea-level rise – is an increasing factor affecting nearly one in five threatened or near-threatened species, according to this study. Hooded seals were among them and have dropped in abundance by 90 per cent in the North-eastern Atlantic Arctic over the past few decades (Maxwell *et al.*, 2016).

The insatiable hunger for animal foods is driving the expansion of intensive farming and industrial fishing such that more than a third of the world's land and nearly 75 per cent of freshwater resources are now used for crop or livestock (grazing or animal feed) production (IPBES, 2019). This comes largely at the expense of tropical forests, wetlands and grasslands and the plants and animals that inhabit them.

The human appetite for meat and dairy comes at a high price

The environmental impact of meat and dairy products far exceeds that of plant foods; meat, fish, eggs and dairy use around 83 per cent of the world's farmland and contribute 56-58 per cent of food's different emissions but only provide 37 per cent of the protein we eat and 18 per cent of calories (Poore and Nemecek, 2018).

A study published in the journal *Science of the Total Environment* revealed how livestock production is pushing the expansion of grazing and animal feed cropland into areas of high biodiversity. Many of the

places seeing the greatest shifts in land use – from forest to livestock – are in countries with the largest number of species. By 2050, given current trends, this study predicts that these countries might have to increase the amount of land used for livestock by up to 50 per cent. They recommend that people reduce their consumption of animal foods, replacing them with more sustainable plant foods and say a future with a lower demand for meat, fish, eggs and dairy would drastically reduce habitat and biodiversity loss, fossil fuel energy use, greenhouse gas emissions and pollution while providing a nutritious diet that could greatly improve global health (Machovina *et al.*, 2015).

If trends continue, greenhouse gas emissions from animal agriculture will rise as land for grazing and animal feed crops expands to meet the ever-growing demand for animal foods. This will lead to even more significant losses of biodiversity, scientists say, especially in South Asia, Sub-Saharan Africa and South America (Westhoek *et al.*, 2011).

The relationship between biodiversity and climate change runs both ways. Climate change is an important driver of the loss of biodiversity. At the same time, the deterioration of natural habitats, such as rainforests, is contributing to climate change as trees and other plants that store carbon are lost.

The relentless exploitation and expansion of animal agriculture is destroying the natural habitats of animals and plants all over the Earth, on land and in the oceans, leading us into what now has been recognised as the sixth mass extinction. We don't have to do this – it's a choice and there is still time to put a halt to the destruction.

Meat, fish, eggs and dairy

use 83% of the world's farmland

contribute 56-58% of food emissions

but provide only 37% of the protein we eat

and just 18% of our calories

Source: Poore and Nemecek, 2018.

Deforestation is being driven by the hunger for meat

One million under threat

"The evidence is crystal clear: Nature is in trouble. Therefore we are in trouble."
Professor Sandra Díaz, co-chair of the United Nations' Global Assessment Report on Biodiversity and Ecosystem Services.

One million species of animals, insects, plants and the places they live are currently under threat and we are undermining the entire infrastructure on which human life depends. From the smallest of creatures to entire ecosystems, we destroy them at our peril.


Common UK bumblebee

Bees are in drastic decline, disappearing at rates consistent with a mass extinction. In 2014, the first-ever assessment of all European wild bees (nearly 2,000 species), prepared by the IUCN and published by the European Commission, found that nearly one in ten species were threatened with extinction. Population decline, they said, was mainly due to habitat loss because of agriculture intensification and the increasing use of pesticides and fertilisers. However, the report warned that 80 per cent of European bees have unknown population trends and some are suspected to be in a critical state of decline. The lack of information about these species meant that a threat category could not be assigned and the situation could be much worse than reported (Nieto *et al*., 2014).

Bumblebees

Of all the wild bees in Europe, bumblebees are the best studied group. There are about 19 different species of bumblebee in the UK, 68 in Europe and around 250 in the world. Well-suited to cooler weather, bumblebees' fluffy hair and ability to generate heat while flying often permits them to be the first bees out in spring. They are among the most important pollinators of food crops and play a key role in pollinating tomatoes, peppers, squash and berries amongst other crops important to humans. But they are living under threat, due to the rise of industrial agriculture, habitat loss, deforestation, increased pesticide use and climate change. According to the European Red List of bees, around a quarter of bumblebee species in Europe are threatened with extinction (Nieto *et al*., 2014).

A study from the University of Ottawa in Canada, looking at 66 different bumblebee species across Europe and North America over a 115-year period (from 1900 to 2015), found evidence of rapid and widespread decline (Soroye *et al*., 2020). Lead author, Peter Soroye, PhD student at the University of Ottawa in Ontario, Canada, said: "Our results show that we face a future with many less bumblebees and much less diversity, both in the outdoors and on our plates." Soroye warns: "If declines continue at this pace, many of these species could vanish forever within a few decades."

Bees are just part of a much wider picture of population declines. By comparison, of groups that were comprehensively assessed in Europe; 59 per cent of freshwater molluscs, 40 per cent of freshwater fish, 23 per cent of amphibians, 20 per cent of reptiles, 17 per cent of mammals, 16 per cent of dragonflies, 13 per cent of birds, nine per cent of butterflies and eight per cent of aquatic plants were considered threatened (Nieto *et al*., 2014).

When discussing threatened species, most attention tends to focus on larger animals but conservation scientists are equally, if not more, concerned about smaller creatures. A study published in the journal *Biological Conservation* described the state of insect

biodiversity in the world as "dreadful", warning that 40 per cent of all insect species are in decline and could die out in the coming decades. They say that moths, butterflies, bees and dung beetles are particularly threatened along with other insects that help decompose faeces and detritus. Habitat loss by conversion to intensive agriculture over the last six decades, they say, is the main driver of the declines along with the widespread, relentless use of synthetic pesticides in recent times. Unless we change our ways of producing food, they warn, insects will go down the path of extinction in a few decades (Sanchez-Bayo and Wyckhuys, 2019).

Earthworms

Insect apocalypse

The sixth mass extinction that we are currently experiencing includes what has been described as an "insect apocalypse." In 2018, English naturalist, television presenter and author Chris Packham said: "I've been in my garden in Hampshire for the last couple of days. Sunny, plenty of wildflowers. Not a single butterfly. Not one. Nothing. And in the woods a handful of Speckled Woods. I think we are at a point of absolute crisis in our countryside." Anyone who grew up in the 1970s will remember the splattering of dead insects all over the car windscreen that would happen during long journeys – it was carnage. Nowadays, there is hardly anything like as many splattered flies, gnats, moths and wasps. Entomologists call this the "windscreen phenomenon" and experts blame intensive agriculture and the increased use of pesticides over the past 50 years for the massive decline in insect populations.

There are over 23,008 protected areas in Germany including 5,205 Natura2000 sites, 742 Special Protection Areas (Birds Directive), 4,549 Sites of Community Importance (Habitat Directive) and 17,803 sites designated under national laws. A study looking at populations of flying insects in 63 protected areas in Germany found that they have declined by more than 75 per cent over the last 30 years, despite measures in place to preserve ecosystem functions and biodiversity (Hallmann *et al*., 2017). Butterflies are key indicators of the health of the environment. Across Europe, populations of European grassland butterflies are estimated to have halved between 1990 and 2011 with bees and moths following the same trend (European Environment Agency, 2013).

To really understand the potential negative impacts of what is happening to biodiversity we need to appreciate how the small and often unseen organisms do most of the work that keep ecosystems ticking over: insects, fungi, algae, crustaceans, molluscs and so on.

Earthworms

Often overlooked, as they lack the appeal of larger animals, earthworms have been referred to as "ecosystem engineers" because they play an important role in breaking down organic matter (decomposition) freeing up nutrients which help plants and trees grow faster. As a bonus, this process locks carbon in too. Charles Darwin referred to them as "nature's ploughs" saying: "It may be doubted whether there are many other animals which have played so important a part in the history of the world, as have these lowly organised creatures" (Darwin, 1881).

But earthworms are on the decline too; one study found that 42 per cent of fields in England surveyed by farmers were seriously deficient in earthworms – in some fields they were missing altogether (Stroud, 2019). Globally, of the 222 species (out of around 7,000 worldwide) assessed by the IUCN, two are already extinct, six critically endangered, 13 endangered, eight vulnerable, 12 near threatened, 74 considered at lower risk and there was insufficient data on 107 to make an assessment. Habitat loss to agriculture, including land clearance for grazing and animal feed cropland, is one of the main reasons for their demise. Life could become very difficult without

earthworms; we would have less food, more pollution and more flooding.

However, earthworms are not so welcome in boreal forests, which circle the northern hemisphere of the globe, passing through North America, northern Europe and northern Russia – rather like a ring of hair around a balding head. The boreal forest is the world's largest and most intact ecosystem on the planet and holds one-third of the world's terrestrial carbon (Watson *et al*., 2018).

Native earthworms disappeared from this region during the last ice age. The forest floor has adapted to thrive in their absence by accumulating a thick layer of rotting leaves, mosses and fallen wood over mineral soil. These layers of slowly decomposing matter, deposited over years, have created a home for insects, birds and native plants. Invasive earthworms, from Europe and Asia, are now wreaking havoc, devouring this mulchy layer and releasing nutrients that have been stored up over decades. Although generally seen as highly beneficial to soil fertility, scientists say earthworms in this region may increase net soil greenhouse gas emissions (Lubbers *et al*., 2013). In other words, they are upsetting the balance, such that more carbon is released than stored from this vital asset.

This shows how there is simply not a one-size-fits-all approach to biodiversity. The world's natural ecosystems have all developed in their own unique way and disrupting any part of them can have devastating effects, the full consequences of which are unclear.

Seed dispersal

We depend on nature for the important task of seed dispersal. For animals that help in this essential activity, some plant species such as fruit-bearing trees, for example, offer a tasty reward. The indigestible seed coating protects the seed as it travels through the animal's digestive system and is then deposited, at a new location away from the parent tree, in a dollop of natural fertiliser!

Black-and-white ruffed lemurs in Madagascar are capable of dispersing big tree species and as such may play a significant role in carbon sequestration. Listed by the IUCN as critically endangered, the principal threat to their survival is habitat loss due to slash-and-burn agriculture as well as hunting, logging and mining. Ring-tailed lemurs, also in Madagascar, are important seed dispersers and their numbers have declined by 45 per cent over the past 40 years (Brinkmann *et al*., 2014). Deforestation for small-scale but widespread charcoal production, slash-and-burn agriculture and livestock grazing, are all impacting the remaining forests throughout southern Madagascar (Waeber *et al*., 2015).

Elephants contribute to forest ecosystems by distributing seeds and nutrients, but they also help forests store a substantial amount of carbon. By trampling and grazing on young, smaller plants, elephants in west and central African forests (but not in the Amazon) create space for surviving trees to grow larger and therefore store more carbon.

A black-and-white ruffed lemur in Madagascar

A study published in the journal *Nature Geoscience* says that if elephants were to go extinct, the amount of carbon stored in central African rainforests could fall by seven per cent. They say the loss of elephants would reduce the biomass of African forests by about three gigatonnes of carbon – equivalent to 14 years' worth of carbon emissions from the UK (Berzaghi *et al*., 2019). Co-author of the study, Dr Stephen Blake, Assistant Professor of Biology from Saint Louis University in Missouri in the US, says: "The sad reality is that humanity is doing its best to rid the planet of elephants as quickly as it can. Forest elephants are rapidly declining and facing extinction. From a climate perspective, all of their positive effect on carbon and their myriad other ecological roles as forest gardeners and engineers will be lost." There were around a

million elephants in central African rainforests in the early 19th century, now there are only about 100,000. Forest elephant conservation could halt and even reverse this tragic loss.

Sumatran elephants are also critically endangered largely due to oil palm plantations destroying their home. From ice cream and instant noodles, to shampoo, lipstick and animal feed, palm oil is the most widely consumed vegetable oil worldwide and half of all packaged products contain it (WWF, 2018). The oil used in foods is derived from the reddish part of the fruit, while the oil in non-edible products, such as soaps, cosmetics and detergents, is extracted from the seed or kernel. A third product made from oil palms is palm kernel expeller (PKE) or palm kernel cake, which is used as animal feed. Around half of global PKE exports are sent to Europe and more than 80 per cent of that is used for animal feed, while the rest is used in power stations as biomass for co-firing with coal. The beef industries in several Asian economies (notably South Korea, Thailand and Vietnam) took over 20 per cent of PKE exports in 2012 and are emerging as significant PKE consumers (Virah-Sawmy, 2014).

Taken together, palm oil is big business; between 1980 and 2014, global production increased 15-fold; from 4.5 million tonnes to 70 million tonnes and demand is expected to grow by 1.7 per cent per year between now and 2050 (IUCN, 2018). The use of PKE in animal feed illustrates the direct links between elephants and other animals dying and the consumption of meat.

Wilderness areas – going, going, gone!

Wilderness areas are the last places on Earth to contain groups of different species of plants and animals at near-natural levels. They are the only areas left that support ecological processes that can sustain biodiversity, providing the last sanctuary for species that are declining. In the seas, they are the last regions that still contain viable populations of certain predators such as tuna, marlins and sharks (Watson *et al*., 2018a).

Around a fifth of the world's land area is wilderness – mostly in North America, North Asia, North Africa and the Australian continent (Watson *et al*., 2016). However, despite their critical role in humanity's survival, wilderness areas are disappearing at an unprecedented rate. Between 1993 and 2009, an area of terrestrial wilderness larger than India – a staggering 3.3 million square kilometres – was lost (Watson *et al*., 2018a).

Biodiversity in the extremes

In August 2019, a memorial plaque marking Okjökull, the first glacier lost to the climate crisis, was unveiled in Iceland. It will certainly not be the last glacier to be lost and scientists believe that the 400-plus glaciers in Iceland will all be gone by 2200.

Biologists use the term biome to describe a large, naturally occurring community of flora and fauna occupying a major habitat. For example, a biome may include a forest or a treeless frozen tundra. Glaciers are

African forest elephants

often regarded as a part of polar or mountain ecosystems, but scientists now say that they should be considered as a new biome in their own right. Far from being barren, they host a whole ecosystem of unlikely creatures including tiny insects, worms, fungi, algae, bacteria and microscopic animals called tardigrades or water bears.

How did these unlikely microbial hotspots develop? The answer lies in a combination of dust, wind and heat. The most biologically active part of a glacier is its surface, where during summer, interaction between bacteria, algae and wind-blown dust form a layer of cryoconite (from the Greek kryos meaning cold and konis meaning dust). Because the dust is darker than ice, it absorbs more heat from the sun and causes the ice under it to melt, creating water-filled reservoirs called cryoconite holes (Zawierucha *et al*., 2019). The surface of glaciers can be riddled with these holes, some needle-thin – others much wider. These sheltered reservoirs provide the perfect refuge for a hub of activity in which secret ecosystems can thrive.

Iceberg calving

A tardigrade

In 2014, a team of researchers, led by Dr Krzysztof Zawierucha, from the Adam Mickiewicz University in Pozna in Poland, conducted the first worldwide survey of invertebrates inhabiting cryoconite holes in Alpine, Antarctic, Arctic, Himalayan and Patagonian glaciers. They found many new species, some of which are unique to their habitat (Zawierucha *et al*., 2014). Zawierucha said: "In Arctic regions the big predator is the polar bear, but in cryoconite holes it is the water bear, which feeds on bacteria and algae. They are the toughest organisms on Earth."

Tardigrades survive the long winter by drastically slowing their metabolism and they may even possess antifreeze proteins. They enjoy a reputation as being the toughest, most resilient creatures on Earth. In fact, hardy tardigrades have survived all five mass extinctions on Earth since they evolved about 500 million years ago and could survive after humans are long gone, if we don't kill them all first. We might even learn some important climate resilience lessons from these tiny water bears. However, scientists are racing against time as the ice is melting due to the climate crisis – and animal agriculture is one of the main contributors.

Human activity has condemned vast numbers of mammals, birds, amphibians, reptiles, insects and microorganisms to an early grave. Ecosystems on which our economies, livelihoods, food security, health and quality of life depend are deteriorating more rapidly than ever. We are destroying the foundations of life worldwide with little or no regard for the consequences for us and the other species with which we share the planet.

Primates

"Unsustainable human activities are now the major force driving primate species to extinction."

Estrada *et al*., 2017.

Primates are our closest biological relatives and some of them, we know quite well: the lemurs of Madagascar, the great apes of Asia and Africa and the diverse monkeys of the tropical world. But there are countless other engaging, peculiar and secretive creatures that most of us have never seen, even on TV: pottos and tarsiers, lorises and galagos, angwantibos and more (IUCN/SSC, 2021).

There are more than 500 known primate species distributed across the Neotropics, mainland Africa, Madagascar and Asia. They are present naturally in 90 countries; however, two-thirds of all species occur in just four countries – Brazil, Madagascar, Indonesia and the Democratic Republic of the Congo. They are an essential component of tropical biodiversity, contributing to forest regeneration and ecosystem health.

Around 60 per cent of the world's primate species are threatened with extinction because of deforestation, habitat loss and fragmentation, large- and small- scale agriculture, cattle-ranching and overexploitation. Other drivers of species loss include hunting (bushmeat) and the illegal trade of primates as pets and primate body parts, along with emerging threats such as climate change (Estrada *et al*., 2017).

The production of commodities such as soya beans, palm oil, natural rubber and beef, scientists say, has direct and indirect impacts on biodiversity and primate populations. A central concern is that global dietary changes, including greater meat consumption because of rising living standards, will encourage many primate-range countries to convert even more forested land into monocultures to meet global demands. To protect primate habitats, it is imperative, they say, to reduce the world's demand for these agricultural products and the consumption of meat and dairy products (Estrada *et al*., 2019).

Threats to primates:

87% of species in Madagascar are threatened

73% in Asia

37% in mainland Africa

36% in the Neotropics

Estrada *et al*., 2017.

The Primate Specialist Group (PSG) of the IUCN's Species Survival Commission (SSC), produces a list of the world's 25 most endangered primates (see below). The Top 25 list has become a biennial review of those species and subspecies in the direst need – some of which now survive only as a few dozen individuals. By highlighting the danger to a selected few, the PSG hopes to draw attention to the need for urgent conservation measures for these species and to the wider issues of primate conservation.

The PSG writes on the critically endangered primates: "These are the names we have nearly lost: these are the primates who just barely survived the 20th century, and who – without our immediate intervention – will never survive the 21st.

"Each of the lineages below is unique, in voice and shape and ancient home; each name speaks to a former multitude, long since broken and scattered to a dwindling few. Each handful of survivors is all that remains of an unknown history, woven through deep ages and written in the substance of themselves – each a vital thread in the weft of our living world.

But all their futures are unravelling now, while we stand in distant witness. These are the primates listed as critically endangered, about whom far too little is known: save that their populations are decimated, their homes are charred and fallen; and without our efforts, they will be lost in a handful of years" (IUCN/SSC, 2021a).

An angwantibo

Primates in peril: The world's 25 most endangered primates 2018-2020

MADAGASCAR	THREAT
Bemanasy mouse lemur	Habitat loss and degradation driven by wood extraction, slash-and-burn cultivation for cattle expansion
Lake Alaotra gentle lemur	Habitat loss, habitat degradation and hunting. Land use change; marsh burning to establish irrigated rice fields and to access fishing
James' sportive lemur	Habitat loss, habitat degradation, deforestation and hunting
Indri	Habitat destruction for slash-and burn agriculture, logging and fuelwood gathering
Aye-aye	Habitat destruction (forest degradation, fragmentation and slash-and-burn agriculture) and persecution by some local populations who believe aye-ayes to be an evil omen
AFRICA	
Rondo dwarf galago – Tanzania	Habitat loss due to agricultural encroachment, charcoal manufacture and logging
Roloway monkey – Côte d'Ivoire, Ghana	Destruction and degradation of their habitat and relentless hunting for the bushmeat trade
Kipunji – Tanzania	Forest loss and degradation for agriculture and logging and illegal hunting, plus hunted with log traps and dogs as retribution for crop-raiding of maize
White-thighed colobus – Côte d'Ivoire, Ghana, Togo, Benin, possibly Nigeria	Illegal hunting, snaring, mining, logging and farming threaten their sustained existence
Niger Delta red colobus – Nigeria	Habitat degradation and commercial hunting
Tana River red colobus – Kenya	Continuing deforestation, forest fragmentation and invasive plants challenge the survival, as do agricultural encroachment and unsustainable forest exploitation (building materials, palm wine, medicinal plants, wood for canoe-making, firewood collection)
Western chimpanzee – Côte d'Ivoire, Ghana, Guinea-Bissau, Liberia, Mali,Republic of Guinea, Senegal, Sierra Leone	Habitat loss, climate change (aridity), bushmeat hunting, mining expansion, industrial agriculture and killed in retaliation for crop foraging
ASIA	
Javan slow loris – Indonesia	Capturing individuals to meet the demand for pets is the most severe threat to survival. To avoid being bitten by venomous slow lorises, traders habitually pull out the animal's lower front teeth prior to selling them – many don't survive
Pig-tailed snub-nose langur – Indonesia	Commercial logging, human encroachment, hunting (considered a delicacy) and forest conversion to oil palm plantations
Golden-headed langur or Cat Ba langur – Vietnam	Hunting is the sole cause for the dramatic and rapid population decline

Golden langur – India, Bhutan	Habitat loss and fragmentation, cattle grazing, human encroachment (electrocution on power lines, road accidents and increasingly attacked by dogs), illegal tree felling, fuel wood collection
Purple-faced langur – Sri Lanka	Depleting natural food sources, deforestation, habitat fragmentation and urbanisation pose a serious threat to long-term survival
Skywalker hoolock gibbon – China, Myanmar	Agricultural encroachment, commercial logging, habitat fragmentation and isolation, and hunting (for bushmeat and pet trade) are major threats
Tapanuli orangutan – Indonesia	Forest loss, fragmentation and habitat conversion for small-scale agriculture and large agricultural plantations along with human encroachment and illegal hunting and poaching
NEOTROPICS	
Buffy-tufted-ear marmoset – Brazil	Habitat loss, habitat fragmentation and competition and hybridisation with invasive species, plus yellow fever
Pied tamarin – Brazil	Deforestation, habitat degradation and fragmentation and displacement by other species
Ecuadorian white-fronted capuchin – Ecuador, Peru	Forest loss and fragmentation due to land use changes, mainly for agriculture and ranching. Considered a pest and persecuted and hunted in plantations (corn, bananas, plantain and cacao) and for crab hunting in mangroves
Olalla Brothers' titi monkey – Bolivia	Habitat loss due to fragmented forest/deforestation is the main threat – linked to cattle-ranching, the main economic activity in the region
Brown howler monkey – Brazil, Argentina	Widespread forest loss and fragmentation due to logging, agriculture and cattle-ranching. Attacks by dogs, traffic accidents and electrocution are serious threats to howlers living close to urban areas. Also, diseases such as yellow fever
Central American spider monkey – Mexico, Guatemala, Nicaragua, Honduras, El Salvador, Costa Rica, Panama	Habitat loss and fragmentation due to farming activities such as oil palm plantations and road construction as well as severe hunting pressure, the pet trade and deforestation related to illegal drug trade

Source: Schwitzer *et al*., 2019.

Funky gibbons

Described as stunning gymnasts, soulful singers and loving family members, gibbons differ from great apes (chimpanzees, gorillas, orangutans and humans) in being smaller. They can swing from branch to branch (brachiation) for distances of up to 15 metres at speeds up to 35 miles per hour. They're the only mammal in the world with a ball and socket joint in their wrists (like the ones in our shoulders and hips), making their wrists stronger and more flexible. They can swing skilfully through the trees further and faster than any other ape, making them the quickest and most agile of all tree-dwelling non-flying mammals (IUCN/SSC, 2021b). They can also walk on two feet (bipedally) with their arms raised for balance.

A Skywalker hoolock gibbon

Of the 28 known gibbon species listed by the IUCN, 22 are either endangered or critically endangered and one of these was only recently discovered. In 2017, in the forests of the Gaoligong mountains, which straddle the border between southwest China and northern Myanmar, scientists identified a new species of gibbon distinct from other Chinese gibbons. They named the new gibbon the Skywalker hoolock gibbon (they were Star Wars fans). A full genetic and physical comparison with other gibbons confirmed that they had found a new species that may have diverged from another around half a million years ago.

The newly discovered Skywalker gibbon is facing an uncertain future and is included on the list of the world's 25 most endangered primates. Less than 150 individuals are known to exist in China and the population in Myanmar is unknown but likely to be small and highly threatened because of political instability and associated habitat destruction and uncontrolled poaching (Zhang *et al*., 2020). Agricultural encroachment, commercial logging, habitat fragmentation and isolation, and hunting (for bushmeat and the pet trade) are all major threats for this newly discovered species. Dr Sam Turvey, from the Zoological Society of London, who was part of the team studying the apes, told the BBC: "It's difficult to get into the reserve. You have to hike up to above 2,500m to find the gibbons. That's where the good quality forest usually starts – everywhere below there has been logged" (Morelle, 2017).

Mountain gorillas

Gorillas are our second-closest relatives after chimpanzees. We didn't evolve from them; humans and gorillas took separate evolutionary paths about 10 million years ago, so we share a common ancestor. There are almost eight billion humans on the planet now but there are less than 1,200 mountain gorillas (*Gorilla beringei beringei*). They are among the most endangered animals on Earth.

Gorillas have inhabited the equatorial regions of Africa for thousands of years but conflict, poaching and agricultural expansion have devastated the population over the last few decades, with numbers in this region falling to as low as 250 individuals in 1981. Conservation efforts have helped restore numbers to around 1,200, with 580 in the Virunga Mountains and a similar number in the Bwindi Impenetrable National Park in Uganda (UNEP, 2021).

In 2018, the IUCN changed the classification of mountain gorillas from Critically Endangered to Endangered. However, progress remains fragile and major threats persist. Legal and illegal human entry into gorilla habitats pose both immediate and long-term risks; human disturbance of the animals, disease, injury and death as non-target species of poaching, purposeful killing, habitat degradation and destruction, and climate change-induced changes of habitat, all jeopardise the persistence of mountain gorillas (IUCN, 2020).

Mountain gorillas

In June 2020, Rafiki, a 25-year-old silverback in the Bwindi Impenetrable National Park was killed by poachers who said they were hunting for bushmeat. Johannes Refisch, a United Nations Environment Programme expert on mountain gorillas and Coordinator of the Great Apes Survival Partnership (GRASP), says: "Gorilla-related tourism, a key source of income for local communities, dried up amid the Covid-19 pandemic. As a result, we have seen an increase in illegal activities, as desperate community members enter the parks in search of wild meat, bamboo, timber and other commodities."

Poaching presents a serious threat to mountain gorillas. Some are hunted for their meat but snares set for other mammals, particularly forest antelopes, can trap and kill mountain gorillas too. During a population study in the Virungas in 2018, survey teams destroyed over 380 snares but a mountain gorilla was found dead, trapped in one of them (Hickey *et al*., 2018).

In Uganda, the harvest of wildlife is illegal but bushmeat hunting is commonplace. This has resulted in a covert market with person-to-person exchanges rather than legal open markets. Nearly a third of bushmeat sold in these communities is misrepresented as another species, adding another layer of risk as certain species of wildlife, such as primates and bats, are more often implicated as reservoirs for zoonotic diseases than species like warthog or antelope (Dell *et al*., 2020).

Hunting, preparing and consuming bushmeat can contribute to the spread of viral diseases such as Ebola or bacterial infections caused by *E. coli*, *Salmonella*, *Brucella* or others. One study, that interviewed 292 women who cook for their households and 180 self-identified hunters from 21 villages bordering Murchison Falls National Park in Uganda, found that almost all respondents were aware of the risk of disease spillover from wildlife to people. However, for the hunters, this awareness did not motivate precautionary measures, financial gain was their primary motivation (Dell *et al*., 2020).

As gorilla habitats become increasingly encroached upon, the likelihood of conflict, over resources such as food and water that humans perceive to be theirs, increases (Hockings and Humle 2009). Conflicts arise from gorillas crop-raiding agricultural fields adjacent to parks, smallholder cattle encroaching into protected areas and incidents of direct killing of mountain gorillas by farmers living adjacent to parks. Bwindi gorillas have been known to crop-raid because of the availability of palatable foods (eg bananas, eucalyptus and sweet potatoes) close to the park (Seiler and Robbins 2016). Grazing livestock that encroach into parks may interact with gorillas, negatively impacting them through displacement or disease transmission. As human populations grow and make deeper incursions into the natural habitat of great apes, such conflicts will become more prevalent (Hockings and Humle 2009).

As their habitat is encroached upon, mountain gorillas are now increasingly threatened by the risk of disease transmission from both humans and livestock. One study found that gorilla populations whose habitats overlapped with people and livestock harboured *E. coli* that were genetically similar to human and livestock bacteria, whereas *E. coli* from gorillas whose habitat did not overlap were more distantly related. Alarmingly, 17 per cent of *E. coli* samples from gorillas living alongside people and livestock were resistant to at least one antibiotic used by local people (Rwego *et al*., 2008).

Gorillas are naturally afraid of humans, but through repeated contact, they have become habituated (Robbins *et al*., 2011). Research shows how this increases their vulnerability. One study found that between 1967 and 2008, 26 habituated Virunga mountain gorillas were killed by humans. Three poaching deaths resulted from gorillas being caught in snares set for other animals, 15

were shot by militia groups and eight were killed by villagers or poachers for other reasons – including for bushmeat, to stop crop-raiding and capturing their young for the pet trade. A further 16 died from respiratory diseases, but it is unknown whether these were transmitted from humans.

Great apes are susceptible to human pathogens because of their genetic relatedness to us. In other words, if a viral or bacterial infection affects us, it will likely affect them too. In January 2021, several captive gorillas at a San Diego zoo in the US tested positive for Covid-19, with some experiencing symptoms. In September of the same year, more than a dozen gorillas tested positive for Covid-19 at another US zoo, this time in Atlanta, Georgia. Officials said they believed a member of their animal care team, who was asymptomatic when she came to work, probably transmitted the virus.

The IUCN estimates that 264 to 880 people come into close proximity with mountain gorillas every day (IUCN, 2020). Such tourism can help support the conservation of great apes and their habitats but should only be developed if the benefits outweigh the risks. The IUCN have published guidelines for best practice in great ape tourism; recommending, for example, that tourists do not go any closer than seven metres to habituated apes if wearing an N95 surgical respirator facemask, or 10 metres if not wearing one (Macfie and Williamson, 2010).

Scientists warn that climate change is also likely to affect mountain gorillas with increased temperatures and disrupted rainfall patterns (Thorne *et al*., 2013). These conditions will likely cause changes in habitat quality and the availability of foods such as bamboo, which is dependent on seasonal rainfall (McGahey *et al*., 2013). This demonstrates another link between animal agriculture and the loss of wildlife as a fifth of all anthropogenic greenhouse gases, driving the climate crisis, come from livestock production.

There is some good news, however, despite ongoing civil conflict, illegal poaching and encroaching human populations and agriculture, both populations of mountain gorillas (in the Virunga Mountains and the Bwindi Impenetrable National Park in Uganda) have increased in numbers. However, we can't afford to be complacent; even land within protected areas is not safe from clearing. In 2004, for example, illegal settlers cleared 3,700 acres of gorilla forest in Virunga National Park. With the vast majority of unprotected forests being opened up to selective logging and habitat loss and degradation, it is vital that we step up our efforts to conserve the great apes (Strindberg *et al*., 2018).

Chimpanzees

Chimpanzees (Pan troglodytes) are a species of great ape native to the forest and savannah of tropical Africa. They have four subspecies: Western chimpanzee, Central chimpanzee, Eastern chimpanzee and Nigeria-Cameroon chimpanzee. The last three are listed by the IUCN as Endangered but the Western chimpanzee is listed as Critically Endangered.

Along with the bonobo (*Pan paniscus*), the chimpanzee is the closest relative to humans and like us, they are complex, social, intelligent, curious and capable of brutality and kindness. They live in groups of up to 150 individuals, make and use tools, hunt in groups and share food. They separate into smaller groups when foraging during the day but come back together to sleep at night. It's been suggested that chimpanzees provide a window into the lives of our common ancestors: male-dominated, warlike, monkey hunters. However, others have challenged this view, pointing out the characteristics of our other closest living relatives, bonobos; female-dominated pacifists that substitute sex for aggression (Wilson, 2021).

A young chimpanzee

Chimpanzees have by far the widest geographic distribution of any great ape, with a range of over 2.6 million square kilometres (IUCN, 2016). They can be found from southern Senegal across the forested belt north of the Congo River to western Tanzania and western Uganda. They are now extinct in four of their 25 range countries; Gambia, Burkina Faso, Togo and Benin. Where they numbered perhaps one million at the turn of the 20th century, today it's estimated there are 172,000 to 300,000 chimpanzees remaining (IUCN, 2016).

Although there are more chimpanzees than many other endangered primates, their numbers in the wild are rapidly declining. This is largely because, even though they are listed as Endangered or Critically Endangered, chimpanzees are still hunted for their meat. All killing, capture or consumption of great apes is illegal, however, the IUCN says that poaching remains the greatest threat to most chimpanzees (IUCN, 2016).

While bushmeat was a popular source of protein for local communities in the past, the scale of hunting has increased dramatically and has become heavily commercialised with much more of the meat now going to urban residents. Growing human populations and the increasing urban demand has led to the emergence of a booming bushmeat trade with unprecedented harvest (kill) rates and the consequent decline of numerous wildlife populations (Cawthorn and Hoffman, 2015). The Jane Goodall Institute say: "The commercial bushmeat and illegal exotic pet trades give poachers incentives to kill even nursing mothers."

Large-scale biodiversity loss is now globally recognised as an ecological disaster with substantive evidence revealing many places where once vibrant wildlife populations have been hunted to extinction. The 'bushmeat crisis', a term coined to describe the overharvesting of wildlife for food, is now seen as the greatest threat to biodiversity in some regions. Most large mammal species in Kilum Ijim in Cameroon, for example, have become locally extinct due to hunting over the last 50 to 60 years, including elephants, buffalo, bushbuck, lions, leopards and chimpanzees (Cawthorn and Hoffman 2015).

Another main threat to chimpanzees is the conversion of forest to farmland across Africa. Expanding agriculture, livestock farming, urbanisation and felling of trees for timber, firewood and charcoal burning, and widespread fires are all contributors to forest losses. Subsistence, or slash-and-burn agriculture, has severely reduced the availability of chimpanzee habitat (IUCN, 2016). Such habitat loss is especially acute in West Africa, where it is estimated that more than 80 per cent of the region's forest cover had been lost by the early 2000s (Kormos *et al*., 2003).

The so-called 'cattle corridor' of Uganda stretches from the northeast (eg Kotido District), through central (eg Nakasongola District) to southwest Uganda (eg Rakai and Ntungamo Districts). The constant grazing of large herds of livestock during the dry season in the central forest reserves in this region causes damage to young trees through compaction of soils, rendering them prone to erosion and nutrient loss (Kagolo, 2010). In the past, communal land ownership and limited cultivation enabled farmers to move livestock more easily, which reduced the pressure on the land. Changes in land ownership and land use have reduced mobility as a coping strategy to drought, thus contributing to the degradation of rangelands (Byenkya *et al*., 2014).

Extensive land conversion in eastern Democratic Republic of Congo, western Rwanda and western Uganda has destroyed much of the forest used by chimpanzees in the foothills and lower slopes of mountain ranges there. Rising human populations are expected to lead to further widespread conversion of forest to agricultural land. Along the northern border of the forest-savannah boundary, forests are also being lost to fires and grazing of livestock (IUCN, 2016). Uganda's natural forests are being lost and degraded at one of the highest rates in the world through encroachment, deforestation and degradation as forest land is converted for farming and other land uses. Chimpanzees are also sometimes killed intentionally – even poisoned – by farmers protecting their crops or as retribution for crop-raiding (Brncic *et al*., 2010).

In Sierra Leone, for example, agriculture is primarily small-scale subsistence farming that relies on the practice of slash-and-burn. As the population increases, demand for land grows, farms are pushed into steeper slopes and more difficult terrain and require ever more forest clearance and shorter periods of fallow. All of these have serious consequences for chimpanzees who lose habitat and are more likely to raid crops from the encroaching farms. Such trends are likely to increase as more natural habitat is converted for agriculture (IUCN, 2016).

Farmers burn land to clear areas for planting, while herders burn to increase grazing for cattle and hunters burn to be able to spot their prey more easily. A report from the Ugandan Ministry of Water and Environment says that many fires are intentionally set

by herders at the onset of the dry season to encourage re-growth of new grass for livestock during the rainy season. Some of the fires are set by hostile communities neighbouring forest plantations in retaliation to the planters' refusal to allow them to use parts of the licensed areas to grow crops (Ministry of Water and Environment, 2016).

The effects of climate change are also being felt as uncommonly long dry seasons lead to the accumulation of dry matter in and outside forests, leading to ideal conditions for the rapid spread of fires. When fires are not controlled, vegetation and wildlife can be unnecessarily destroyed. One village in south-eastern Koinadugu District in Sierra Leone reported a large group of chimpanzees that were trapped and killed by an out-of-control bush fire (Brncic *et al*., 2010).

Zoonoses and disease outbreaks are a significant threat to chimpanzees; Ebola, for example, is a major driver of decline in central chimpanzee populations (IUCN, 2016). Viruses that are relatively benign in humans can also be lethal in ape populations. Respiratory viruses of human origin, for example, have caused disease in wild apes across Sub-Saharan Africa and pose a significant and growing threat to chimpanzees.

Respiratory diseases, thought to be transmitted from people, are the leading cause of illness and death among chimpanzees in Gombe Stream National Park in Tanzania and Kibale National Park in Uganda. Other respiratory viruses that can jump from humans to chimpanzees have been found in Cote d'Ivoire and Tanzania. Rhinovirus C has caused chimpanzee deaths in Uganda and coronavirus OC43 of human origin has caused mild respiratory disease in Cote d'Ivoire (Negrey *et al*., 2019). Common human coronaviruses, including types OC43, 229E, NL63 and HKU1 usually cause mild to moderate upper-respiratory tract illnesses in people, like the common cold (CDC, 2020). Of course, this raises concerns about Covid-19 being transmitted from humans as it too is caused by a coronavirus.

As well as the IUCN guidelines previously mentioned – minimum observation distances and facemasks – other measures have been taken. At Gombe National Park in Tanzania, giving chimpanzees bananas has been discontinued as, along with season, it was seen to be the strongest predictor of chimpanzee respiratory illness.

Due to high levels of poaching, loss of habitat caused by expanding agriculture and other human activities and infectious diseases, chimpanzees have experienced huge declines over the last three decades or so and it is feared that this will continue (IUCN, 2016). Although conservation efforts have increased significantly, the IUCN say that populations may continue to suffer losses based on the rapid growth of human populations in sub-Saharan Africa, continuing poaching for bushmeat, the commercial bushmeat trade, the arrival of industrial agriculture (which requires clear-cutting of forest), corruption and lack of law enforcement, lack of capacity and resources and political instability in some areas (IUCN, 2016).

Future challenges

All great apes are protected by national laws and international conventions; it is illegal to kill, capture or trade live individuals or their body parts, wherever they occur. Despite this protection, the combination of widespread illegal poaching, agricultural expansion and Ebola has been catastrophic for gorillas and chimpanzees.

Another emerging threat is industrial-scale forest conversion for agriculture. For example, as tropical Asia nears capacity for oil palm plantations, producers are now heading to African countries with appropriate rainfall and suitable soil and temperature conditions (Rival and Lavang 2014). Unfortunately, these areas also tend to be ideal great ape habitats and it is predicted that expansion is likely to hit chimpanzee populations hard in coming years (IUCN, 2016). While subsistence agriculture has slowly encroached on great ape habitats across Africa, global agribusiness could rapidly destroy large swathes of quality habitat. Even worse than selected logging, large plantations require clear-cutting and would increase forest loss with catastrophic consequences for great apes and other wildlife (Strindberg *et al*., 2018).

Around 90 per cent of oil palms grow in areas that were once tropical forests in Malaysia and Indonesia – islands containing some of the greatest biodiversity on Earth. Smaller areas are planted in Africa and Latin America. Slash-and-burn deforestation has been used to clear the way for plantations in Southeast Asia which have come at the expense of species-rich and carbon-rich tropical forests (Vijay *et al*., 2016). This has led to a huge loss of wildlife there, with substantial numbers of elephants, rhinos, tigers and orangutans losing their homes and lives. There is an urgent need to develop guidelines in Africa to minimise the impact of the expansion of oil palm on primates and other wildlife there (Wich *et al*., 2014).

Oil palm is native to West Africa and is found at relatively high densities in areas where people use it to produce palm oil for domestic and commercial use (Humle and Matsuzawa, 2004). Western chimpanzees in Bossou in West Africa rely heavily on oil palms for feeding and nesting. Recent evidence suggests that oil palms are also an important food and nesting resource for other chimpanzee communities in human impacted areas across West Africa (Bryson-Morrison *et al*. 2020).

Despite the widespread awareness about its detrimental effects on tropical biodiversity, land conversion to oil palm continues and future expansion seems likely in Africa. A study assessing how this could affect African primates found a high overlap between areas deemed suitable for oil palms and areas of high conservation priority for primates (Strona *et al*., 2018). If plantations are adjacent to chimpanzee habitats, they will likely raid the plantations for easy and nutritious food, increasing the risk of conflict.

Palm oil is used in close to half of all the packaged products we find in supermarkets – it's also used in animal feed. In 2011, a study for the UK Government revealed that more than a tenth of all the world's palm kernel meal – a lucrative by-product of the production of palm oil – is fed to British animals in livestock and pet food, none of which was from certified sources (DEFRA, 2011). The animal feed sector is not subject to the same level of scrutiny, market interest or pressure for sustainability.

Reconciling a large-scale development of oil palm in Africa with primate conservation will be a great challenge – which is no surprise given the dramatic detrimental effects of oil palm cultivation on biodiversity in Southeast Asia (Strona *et al*., 2018). The IUCN says effective policies are needed to stop the clearing of tropical forests for new oil palm plantations. You can also help by choosing products that use sustainable palm oil, cutting down on the amount of palm oil you buy and of course, by going vegan.

If primate habitats continue to be destroyed by human activities such as poaching, encroachment, deforestation, agricultural expansion and so on, it seems likely that more species will face extinction – the long-term consequences of which remain unclear. Great apes, for example, play key ecological roles in forest ecosystems; without these large-bodied seed dispersers, forests will fail to regenerate (Strindberg *et al*., 2018). A significant increase in regional, national and global awareness is needed along with a change in political will with financial commitments to endangered species conservation.

The problems facing primate conservation have deep roots, according to the Jane Goodall Institute, including human population growth, the staggering scale of poverty and disease, lack of economic opportunity, political indifference and corruption, conflict and a lack of community involvement in managing natural resources. They say: "To begin to make a difference in the face of such fundamental challenges requires a holistic, multi-pronged response" (Jane Goodall Institute, 2022).

The importance of forests

"In my journal I wrote that whilst standing in the midst of the grandeur of a Brazilian forest 'it is not possible to give an adequate idea of the higher feelings of wonder, admiration, and devotion which fill and elevate the mind.'"

Charles Darwin, 1887.

Forests are vitally important for sustaining life on Earth and play a major role in mitigating climate change. During photosynthesis, trees absorb carbon dioxide, a major greenhouse gas, from the air and use the carbon, in combination with energy from sunlight, to build their trunks, stems and roots. This locking away of carbon is called "carbon sequestration". The part of the tree that lies underground is an important carbon sink in forest ecosystems, estimated to store around 40 per cent of all land carbon (Jiang and Wang, 2017).

Trees and plants release oxygen during photosynthesis and it's estimated that up to 20 per cent of the world's oxygen comes from rainforests – which is why they have been referred to as the lungs of the world. This figure has recently been questioned as some of the oxygen released is then used up in growth (in respiration) and by animals and microorganisms that live in the forest. However, their important role in carbon storage is widely accepted.

Carbon in, oxygen out

In this way, forests serve as a global asset, able to absorb and store carbon for long periods of time. When forests are felled to make way for agricultural land, they become a major contributor of carbon dioxide which is released back into the atmosphere. Deforestation represents a double-whammy for biodiversity in terms of habitat loss plus the additional negative impact on the environment from the loss of carbon storage contributing to climate change.

The biggest threat to forests is agriculture

Source: UN News, 2019a.

Tropical rainforests, found in hot, humid environments in equatorial climates, contain the most diverse range and highest volume of plant and animal life anywhere on Earth. Professor Marten Scheffer and colleagues from the Department of Aquatic Ecology and Water Quality Management at Wageningen University in the Netherlands said of rainforests: "They are among the most charismatic as well as the most endangered ecosystems of the world" (Scheffer *et al*., 2018).

Rainforest cleared for cattle grazing

The Amazon forest biome, including the Amazon rainforest, is biologically the richest region on Earth, hosting around 25 per cent of global biodiversity (Mahli *et al*., 2009). It is one of Earth's last refuges for jaguars and pink river dolphins and it is home to sloths, black spider monkeys and poison dart frogs. A study published in *Nature Scientific Reports* found populations of the harpy eagle, the Earth's largest eagle, are dwindling as tree canopies in the Amazon rainforest disappear along with the eagle's preferred prey (Miranda *et al*., 2021).

In addition to the vast numbers of animals, plants, insects and microorganisms that we know of inhabiting the rainforests, scientists say there may be many millions more undiscovered species – we risk losing them forever if deforestation is allowed to continue.

According to the United Nations, the biggest threat to forests is agriculture, they say that it is the principal global driver of deforestation because of the extent to which forests are being converted to farmland for grazing and animal feed crops (UN News, 2019a).

Forest fragmentation

Dr Erika Berenguer, from the University of Oxford, says that clearing land for beef production is the biggest driver of forest fragmentation, rather than timber or making space to produce palm oil or soya beans. Berenguer says: "Typically, gangs use a chain slung between two tractors to knock down trees quickly and at an industrial scale. Once the felled trees are dry enough, they are burned to leave the ground clear for cattle ranching" (Vaughan, 2019).

As agriculture expands, many of the world's last tropical wildernesses, from the Amazon to Borneo to the Congo Basin, are being penetrated by roads. Writing in the journal *Trends in Ecology and Evolution*, Professor Bill Laurance from the Centre for Tropical Environmental and Sustainability Science at James Cook University in Brisbane has issued stark warnings about what happens when highways carve up the forest.

Tropical rainforests are characterised by uniquely dark, humid and stable microclimates and they sustain many species suited to the interior of the forest – species that shy away from the forest edges and are unable to cross clearings. Large numbers of beetles, flies, ants, bees, butterflies, amphibians, reptiles, birds, bats, small and large mammals avoid even narrow clearings. New roads, highways, power lines and gas lines are rapidly expanding into tropical forests increasing habitat fragmentation, road kill, hunting (bush-meat harvesting), as well as forest fires.

These clearings also enable species invasion, for example, of fire ants, earthworms, non-forest vertebrates and weeds (plants considered undesirable in a particular situation). Little fire ants spread through African rainforests 60 times faster along logging roads than through undisturbed forest and can kill or blind native species such as monkeys, apes, leopards and insects. Laurance warns: "As Pandora quickly learned, it was much harder to thrust the evils of the world back into the box, than to simply not open it in the first place" (Laurance *et al*., 2009).

Close to tipping point

Agriculture, and to a lesser degree logging and urbanisation, have chopped great swathes of tropical forest into fragments, disrupting habitats and reducing biodiversity. Scientists at the Helmholtz Centre for Environmental Research in Leipzig, Germany studied high-resolution satellite images revealing more than 130 million fragments of tropical forest across America, Africa and Asia-Australia. Using modelling techniques to predict what will happen if fragmentation continues, they said that all three continents are close to a critical tipping point beyond which fragment numbers will accelerate. This, they say, will have severe consequences for biodiversity and carbon storage. They offer a glimmer of hope, saying that if deforestation was slowed and reforestation increased, tropical forest cover could be preserved (Taubert *et al*., 2018).

Over the past decade, previous governments have managed to reduce deforestation in many areas. However, satellite images show that deforestation in the Brazilian Amazon rainforest has increased rapidly since Jair Bolsonaro, a climate change sceptic, became president of Brazil in January 2019. Brazil contains 60 per cent of the Amazon rainforest.

According to data from the National Institute for Space Research (INPE), deforestation of the Brazilian Amazon has surged above an area equivalent to three football fields a minute (INPE, 2019), pushing the world's biggest rainforest closer to a tipping point beyond which it cannot recover.

It's a desperate situation, zero-deforestation is within reach, but it requires the political will to act now before it's too late. You don't have to wait for change: by going vegan, you could help reduce the driving force behind deforestation and if enough of us do it, protect rainforest biodiversity.

Grassland biomes in crisis

"Human impacts on the natural environment have reached such proportions that in addition to an 'extinction crisis', we now also face a broader 'biome crisis'."

Hoekstra *et al*., 2005.

There are two main types of grasslands; tropical and temperate. In all these regions grasses are the naturally prevailing vegetation. Collectively they are known as "grassland biomes". The relentless expansion of agriculture has caused grassland biomes to steadily shrink, endangering native plants and animals.

Grassy biomes

Tropical grasslands

Tropical grasslands include the savannahs of sub-Saharan Africa and Australian rangelands.

Savannahs occupy a fifth of the Earth's land surface and are characterised by the coexistence of trees and grasses. They are found where there is not enough rain to support a forest, but not so little that desert forms. It can be a delicate balance and they are among the ecosystems that are most sensitive to changes in land use and climate (Sankaran *et al*., 2005).

According to Dr Brett Murphy, of Charles Darwin University in Australia, grassland biomes are considered poor cousins of tropical rainforests. In areas of high rainfall, the diversity of vertebrates in grassland biomes can be just as high as in rainforests and Murphy argues that these biomes should be recognised as critical, but increasingly threatened, stores of global biodiversity (Murphy *et al*., 2016).

The African savannah is home to a wide variety of grazing animals, such as zebra, gazelles and wildebeest. They are preyed on by predators such as cheetahs, lions and leopards. You can also find jackals, hyenas and predatory birds there. Some animals, such as elephants and buffalo, move around the savannah throughout the year, searching for food and water.

Large numbers of insects, such as grasshoppers and beetles, live above ground feasting on vegetation. Below ground, you can find ants and termites. In fact, there are more species of termites in African savannahs than anywhere else in the world. They are one of the few animals which can break down cellulose from dead wood. Therefore, they play an integral role in reintroducing nutrients from decaying plants into the soil which helps to aerate it. They live in big colonies and many build large mounds that can be several metres high, contributing to a unique landscape. These mounds offer shelter to other animals such as scorpions, lizards, snakes, millipedes and beetles. Specialist termite feeders, such as the aardvark, consume huge numbers of termites in one sitting using their long sticky tongues to penetrate inside the termite mounds and fish out the termites. Other savannah animals that feed on termites include frogs, lizards, bats and many bird species. This diverse community of organisms interact in a complex but balanced ecosystem that has evolved over hundreds, if not thousands, of years.

Human interference and the destruction of natural habitats have resulted in many of the native animals of the African savannah becoming endangered.

Zebras

Grévy's zebra is the largest living wild equid and the most threatened zebra, listed by the IUCN as endangered. They have tall, large ears and their stripes are narrow. More than 15,000 once lived in countries such as Kenya and Ethiopia. Now, there may be less than 2,000 individuals. According to the IUCN, population decline is due to habitat degradation and loss induced by extremely heavy grazing by livestock. Disease from contact with unvaccinated livestock and competition with other animals, especially over access to water and high-quality rangeland, has further added to their decline.

Grévy's zebra

Elephants

African savannah elephants are the largest species of elephant and are the biggest terrestrial animals on Earth. They have very large ears and their front legs are noticeably longer than their hind legs. Less than a hundred years ago, as many as 10 million wild elephants roamed the African continent. Decades of poaching, conflict and habitat loss have decimated populations and the number of individuals left in the wild is severely reduced.

An African savannah elephant

In 2016, the Great Elephant Census, the first ever pan African survey of savannah elephants, estimated that there were only around 350,000 individuals across 18 countries. It confirmed massive declines finding that populations had fallen by 30 per cent (144,000 elephants) between 2007 and 2014 alone and continue to fall by eight per cent per year (Chase *et al.*, 2016). In 2020, the IUCN listed them as endangered. Previously, African savannah and forest elephants were treated as a single species and listed as vulnerable. Although poaching them for ivory in the 1970s and 1980s reduced populations, the loss of grassland to agriculture has decreased numbers more recently. According to the IUCN: "Rapid land use change by humans is driving the direct loss and fragmentation of habitat for African Savannah Elephants and is an increasing threat to populations across their range" (IUCN, 2022).

African wild dogs

African wild dogs are the largest wild canine in Africa and are mostly found in arid and savannah regions. They are team-players and hunt in packs, preying on medium-sized ruminants such as gazelles and antelopes. When running, they can reach speeds of up to 40 miles per hour. They are very social animals and are known to share food, assist weak pack members and collectively care for pups, which are prioritised over dominant pack members for feeding. They were once found throughout the African continent but have now disappeared from most of their geographic range. The IUCN lists them as endangered and estimates that there

are as few as 1,400 mature individuals left and that number is decreasing. They are threatened by habitat fragmentation, human persecution and disease outbreaks. Not only are they being displaced by agricultural expansion, but African wild dogs are often hunted and killed by farmers who fear for their livestock.

Savannahs can also be found in South America, Asia and Australia. The sparsely populated savannahs of northern Australia represent the largest intact savannah on Earth, with very little land-clearing having occurred. There is, however, an active push by the local government to develop northern Australia for large-scale agriculture (Murphy *et al*., 2016).

Changing land use is the most serious threat to biodiversity in grassland biomes, especially in areas where intensive agriculture is viable. Rates of clearing have been very high in recent decades, exceeding rates of tropical forest loss, yet have received little public attention. The Brazilian Cerrado – a hotspot of plant diversity – has been extensively cleared for agriculture, with more than half of it lost in the last 50 years. The grassland biomes of mainland Southeast Asia and India have also been extensively cleared over the last century (Murphy *et al*., 2016).

Losing carbon storage

Like forests, grasslands take carbon out of the air and store it deep in the ground; the roots of deep-rooted perennial plants may grow as deep as 10 feet into the soil. Grasslands cover a greater area than tropical rainforests and are critically important to global carbon and energy cycles. They store about a third of the world's land-based carbon. In the Great Plains of the US, for example, cropland expansion for animal feed is driving the release of carbon stores. It is estimated that ploughing up land for cropland expansion in the US, releases as much carbon dioxide into the air annually as 31 million cars (Spawn *et al*., 2019).

Temperate grasslands

Temperate grasslands are found in every continent except for Antarctica. They include the Eurasian steppe, Argentinian pampas, Australian downs, South African veld and the central North American plains and prairies.

Much of the grasslands in North America have been converted for animal feed crops or grazing. Between 2008 and 2016, croplands in the US expanded at a rate of over one million acres per year (Lark *et al*., 2020). This loss of grasslands to agriculture has unknown long-term consequences but has already affected many species, including monarch butterflies – key indicators of insect biodiversity.

African wild dogs

Western monarch butterflies

Monarch butterflies

Between four and 10 million monarch butterflies once inhabited the California coasts before dropping to just over one million at the end of the 1990s. In the years that followed, the population levelled off at around 200,000, but in 2017, numbers crashed to fewer than 30,000 (Canon, 2021).

What drove their drastic decline is clear; their natural habitats in grasslands across the US are being destroyed. Commercial agriculture is eating away their range. Genetically modified corn and soya, the vast majority of which is used for animal feed, is engineered to be resistant to herbicides. This has led to the widespread destruction of milkweed (among other plants), the only plant that the monarch butterfly larvae eat. Of course, monarchs are also susceptible to climate change. That's partly why they are considered a so-called "indicator species" revealing the devastating toll taken on other insects and ecosystems (Canon, 2021).

This annihilation of wildlife comes with an ever-decreasing return in terms of food security. A study in the journal *Nature Communications* found that croplands moving onto lower-quality land, in less-suitable regions, offer diminished production benefits at a disproportionate cost to wildlife. They concluded: "Our findings demonstrate a pervasive pattern of encroachment into areas that are increasingly marginal for production, but highly significant for wildlife, and suggest that such trade-offs may be further amplified by future cropland expansion" (Lark *et al.*, 2020).

Black-footed ferret

The dependence of black-footed ferrets on prairie-dogs have made them especially vulnerable to extinction because their prey were persecuted as agricultural pests during most of the 20th century. Black-footed ferrets are now just hanging on to survival. Once thought to be extinct, concerted efforts have given them a second chance and helped restore the population to nearly 300 individuals across North America. However, habitat loss as grasslands are taken for agricultural use and disease remain key threats to this highly endangered species.

Almost twenty years ago, writing in the journal *Ecology Letters*, scientists warned that in addition to the extinction crisis, we also face a broader "biome crisis" whereby the entire biodiversity and ecological function of the world's terrestrial biomes are at risk because of extensive habitat conversion and the failure to protect habitats. These regions, they say, include some of the most biologically distinctive, species-rich ecosystems on Earth, as well as the last home of many threatened and endangered species (Hoekstra *et al.*, 2005).

Even large ecosystems, the size of the Amazon rainforest, can collapse in just a few decades. In fact, bigger biomes may break up relatively faster than smaller ones, according to research published in the journal *Nature Communications*. They looked at 42 previous cases of regime shift, the term used to describe the change from one state to another. For example, the collapse of fisheries in Newfoundland, the death of vegetation in the Sahel, desertification of agricultural lands in Niger, bleaching of coral reefs in Jamaica and the eutrophication of Lake Erhai in China. They found that bigger and more complex biomes were initially more resilient. However, once they reach a critical tipping point, they collapse relatively faster, like a stack of Jenga bricks tumbling down after a crucial piece has been removed. This, they say, may mean that policymakers may have less time than they realise to deal with the multiple climate and biodiversity crises facing the world (Cooper *et al.*, 2020).

Marine biodiversity

"By the year 2100, without significant changes, more than half of the world's marine species may stand on the brink of extinction."

UNESCO, 2017.

Oceans are the world's largest ecosystem, home to nearly a million known species and many unknown. In the same way that increasing meat production is annihilating wildlife and plants on land, the increasing consumption of fish and other water creatures is having a devastating impact on marine biodiversity and "decades of irresponsible exploitation have led to an alarming level of degradation" (FAO, 2021).

Coral reefs

Running out of fish

The number of fish killed worldwide has risen hugely, according to the United Nations' Food and Agriculture Organisation (FAO), increasing from 20 million tonnes of fish in 1950 to 179 million tonnes in 2019 (FAO, 2021). The increase is likely to continue, with global fish production projected to reach 200 million tonnes by 2029 (OECD-FAO, 2021). Aquaculture (fish farming) is the main driver of growth in global fish production, growing from a share of 47 per cent of total fish production in 2019, projected to overtake the slaughter of wild-caught fish in 2024 and reach 52 per cent by 2029 (OECD-FAO, 2021).

The 'overexploitation' of fish, shellfish and other marine organisms and the development of aquaculture both contribute to the loss of biodiversity in the world's oceans and threaten complex marine ecosystems. Larger fish are being squeezed from both ends; under threat from overfishing and under pressure as numbers at the bottom of the food chain (phytoplankton) decrease due to climate change.

The term overfishing is used when a species of fish is removed from a body of water at a rate at which that species cannot replenish. In 2017, over a third (34 per cent) of the fish stocks of the world's marine fisheries were classified as overfished, compared to 10 per cent in 1974 (FAO, 2020).

Industrial-scale destruction

Of all the different fishing methods used, bottom trawling is the most destructive and is causing unprecedented damage to some of the most vulnerable ecosystems on Earth. Fleets of boats plunder the depths with state-of-the-art technology, massive nets are dragged along the sea floor by deep-water trawlers, destroying sponge beds and deep-sea corals that have taken centuries or even millennia to grow. Corals are now considered an endangered species, with a third of reef corals living under the threat of extinction (IUCN, 2022).

Coral reefs

Coral reefs are made up of tiny animals called coral polyps: soft-bodied animals related to sea anemones. Reefs form when polyps attach to rocks on the seafloor, using calcium carbonate that they secrete, they then multiply and connect with others to form a large colony that acts as a single living organism. Some living corals may date back 2,000 years and reefs may be older than the Egyptian pyramids. Some corals resemble trees, growing up to 33 feet in height and have been

discovered over two miles below sea level – they are often regarded as the rainforests of the sea. They contain a wealth of historical climate and environmental information locked in their calcium carbonate skeletons – we're losing these invaluable climate records which may have been contained in corals for centuries.


Seagrass

Coral reefs support more than a quarter of marine life, but in their 2018 *Living Planet* report, the WWF say that the world has lost about half of its shallow water corals in the last 30 years due to overfishing and warming sea temperatures. If current trends continue, they say, up to 90 per cent of the world's coral reefs might be gone by the middle of this century. The implications of this for the planet and all of humanity, they warn, are vast (WWF, 2018a).

Coral reefs are particularly vulnerable to climate change and when sea temperatures rise, coral polyps expel the colourful algae that live inside their tissues and provide them with most of their energy. This causes the corals to bleach and, unless they recover enough to permit the algae back, they starve. The loss of coastal habitats and coral reefs reduces coastal protection, which increases the risk from floods and hurricanes to life and property for the 100 to 300 million people living within coastal 100-year flood zones – with a one per cent annual risk of flooding (IPBES, 2019).

Corals are a perfect example of where species loss overlaps with climate change. The UN's 2019 IPBES report says that live coral cover on reefs has nearly halved in the past 150 years with the decline dramatically accelerating over the past two or three decades due to increased water temperature, ocean acidification and industrial fishing. They warn that corals may decline by a further 70-90 per cent when global warming reaches 1.5°C above preindustrial levels and by more than 99 per cent at 2°C higher (IPBES, 2019).

Increasing acidity of the oceans is affecting other marine life too. As carbon dioxide from the atmosphere dissolves in the ocean, it increases the acidity of the water and organisms whose shells or skeletons are made from calcium carbonate have to work hard at either repairing their damaged shells or thickening them to survive. If the concentration of atmospheric carbon dioxide continues to rise at the current rate, scientists warn, the oceans will become uninhabitable for many marine organisms by the end of this century (UNESCO, 2017).

Percentage of fish stocks fished at unsustainable levels:

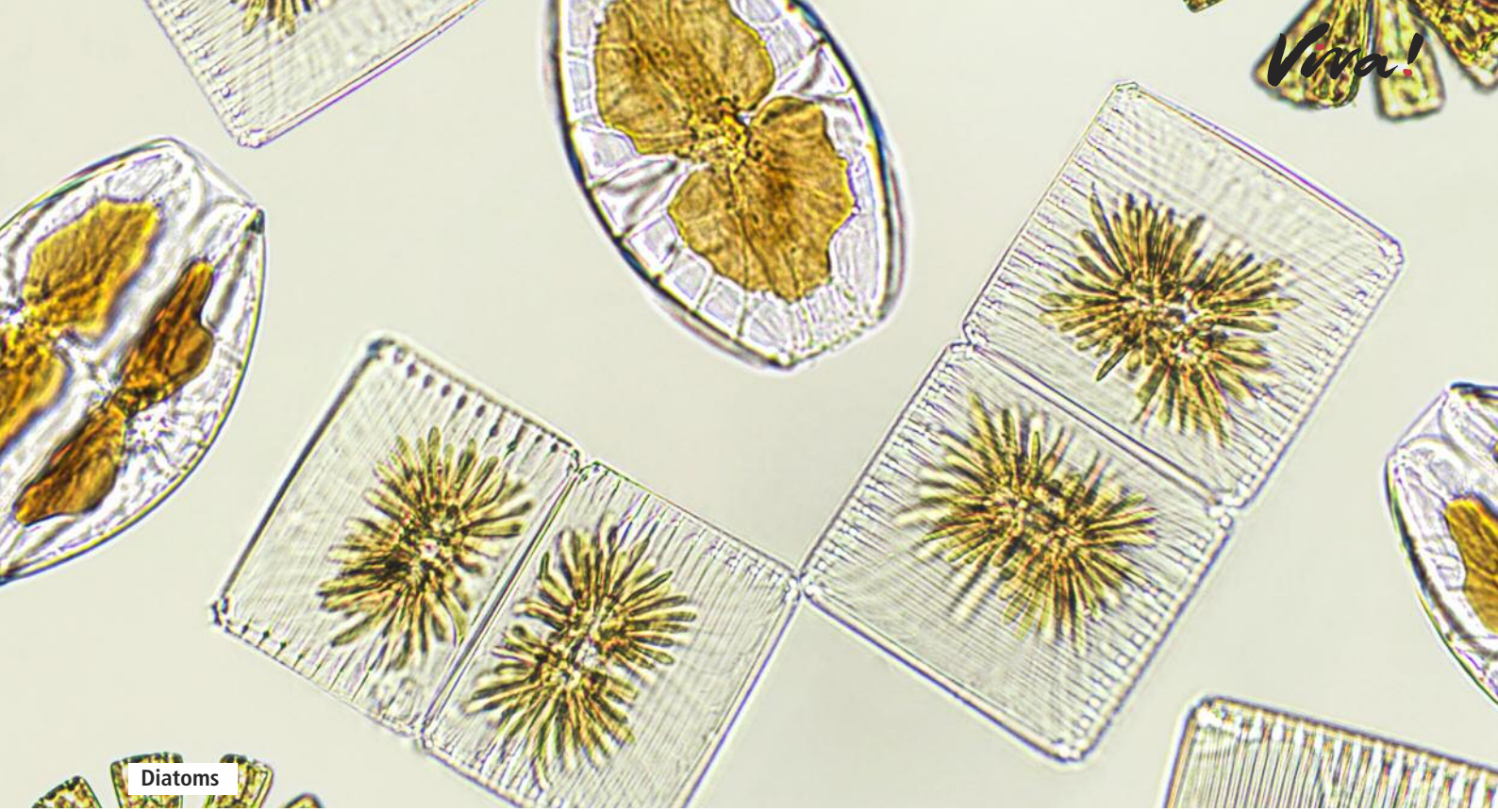
1974
10%

2017
34%

Source: FAO, 2020.

Seagrasses

Seagrasses (marine flowering plants including Zostera, Thalassia, and Posidonia) represent important coastal ecosystems providing nutrient cycling, sediment stabilisation and carbon storage. They too are threatened directly by destructive fishing practices and climate change and indirectly by changes in water quality due to nutrients and contaminants in land runoff. Seagrasses have been disappearing at a rate of 110 square kilometres per year since 1980 and have been lost from almost a third of the area they once inhabited when records began in 1879. Seagrass loss rates are comparable to those reported for mangroves, coral reefs and tropical rainforests and place seagrass meadows among the most threatened ecosystems on Earth (Waycott *et al*., 2009).



Diatoms

Phytoplankton – all I need is the air

As described earlier, tiny microscopic marine algae called phytoplankton use carbon dioxide from the atmosphere for photosynthesis, just like trees, and in doing so, they release oxygen and store carbon. They also form the basis of the ocean food chain for fish and marine mammals (UNESCO, 2017).

In 2010, Boris Worm – a marine biologist at Dalhousie University in Halifax, Canada – and his team, combined satellite-derived observations of phytoplankton with historical measurements stretching back to the early days of oceanography. They found that the average global phytoplankton concentration in the upper ocean was declining by around one per cent every year (Boyce *et al*., 2010). Since 1950, algal biomass (the amount of algae in the water at a given time) has decreased by around 40 per cent, probably in response to ocean warming, but this study suggests the decline has gathered pace in recent years.

More recently, NASA scientists revealed significant declines in the largest type of phytoplankton (diatoms). Analysis using NASA models in combination with ocean satellite data between 1998 and 2012 revealed that populations of these microscopic marine plants in the Northern Hemisphere fell by one per cent per year during this period (Gregg *et al*., 2017).

The advantage of larger diatoms is that they capture carbon and carry it down to the ocean floor when they die, locking it away for thousands of years. According to NASA, phytoplankton transfer about 10 gigatonnes of carbon from the atmosphere to the deep ocean each year (Lindsey and Scott, 2010). Even small changes in the growth of phytoplankton could affect atmospheric carbon dioxide levels. In other words, if it weren't for phytoplankton, atmospheric carbon dioxide would be higher and the climate would be even warmer.

Phytoplankton provide

50%

of the oxygen on earth

Source: UNESCO, 2017.

Falling levels of phytoplankton add yet another layer – along with coral bleaching, overfishing and acidification – to the relentless barrage of assaults the world's oceans are facing. Climate breakdown is already happening and animal agriculture lies at the heart of it. To read more about the links between animal agriculture and the climate crisis, see Viva!'s *Envirocidal* report: viva.org.uk/materials/envirocidal.

UK biodiversity

"We are among the most nature-depleted countries in the world."
Hayhow *et al.*, 2016.

The UK was described as one of the most nature-depleted countries in the world in the 2016 *State of Nature* report, produced by more than 50 different organisations; including the Royal Society for the Protection of Birds, the National Trust, the Marine Conservation Society and the Natural History Museum. Of the nearly 8,000 species assessed in this report, 15 per cent were found to be extinct or threatened with extinction.

Three years on, the situation had not improved when the 2019 *State of Nature* report found that around **one in six native species are threatened with extinction**. They examined more than 8,400 species finding that 15 per cent (around one in six of all animals, insects, plants and fungi assessed) were still under threat of extinction but that two per cent (133 species) have gone for good.

This 2019 report, produced by 70 wildlife organisations and government conservation agencies, found that a quarter of UK mammals and nearly half of all birds assessed were at risk of extinction. It painted a bleak picture, with important species such as hedgehogs, hares and bats, many birds such as the willow tit and the turtle dove and insects such as the high brown fritillary butterfly, all living under threat (Hayhow *et al.*, 2019).

Since 1970, the report says, 41 per cent of species assessed have decreased and 27 per cent are found in fewer places. Butterflies and moths are down 17 per cent and 25 per cent respectively and numbers of grayling butterflies have fallen by more than three quarters. Farmland birds have declined by 54 per cent and the wild cat and greater mouse-eared bat are almost extinct. Only half of UK fisheries are being fished sustainably and 57 per cent of UK waters had their seafloor habitats physically disturbed by bottom contact fishing gear between 2010 and 2015 (Hayhow *et al.*, 2019).

The report says: "Agricultural intensification, driven by UK and European policy, has been identified as the most significant factor driving the decline in species' populations across the UK" (Hayhow *et al.*, 2019). Climate change, urbanisation and pollution also contribute to the loss of wildlife, but to a lesser degree.

Changes in farming practices in recent decades have led to greater food production at the expense of biodiversity. The changes that have had the greatest impact on the UK's nature, according to the report, include the increased use of pesticides and fertilisers; increased stocking rates of sheep and cattle; greater mechanisation and increase in farm size; and loss of nature-friendly features such as field margins, hedgerows, wooded areas and farm ponds. The intensification of farming over the past 50 years has led to loss and fragmentation of semi-natural habitats as agriculture has followed a consistent trend of increasing productivity with associated negative consequences for wildlife (Hayhow *et al.*, 2019).

These losses mirror the global annihilation of wildlife – the sixth mass extinction on Earth that is threatening the natural life-support systems that we rely on for air, water and food.

Number of species threatened with extinction from Great Britain:

7% of urban species

11% of woodland species

12% of farmland species

13% of grassland & heath species

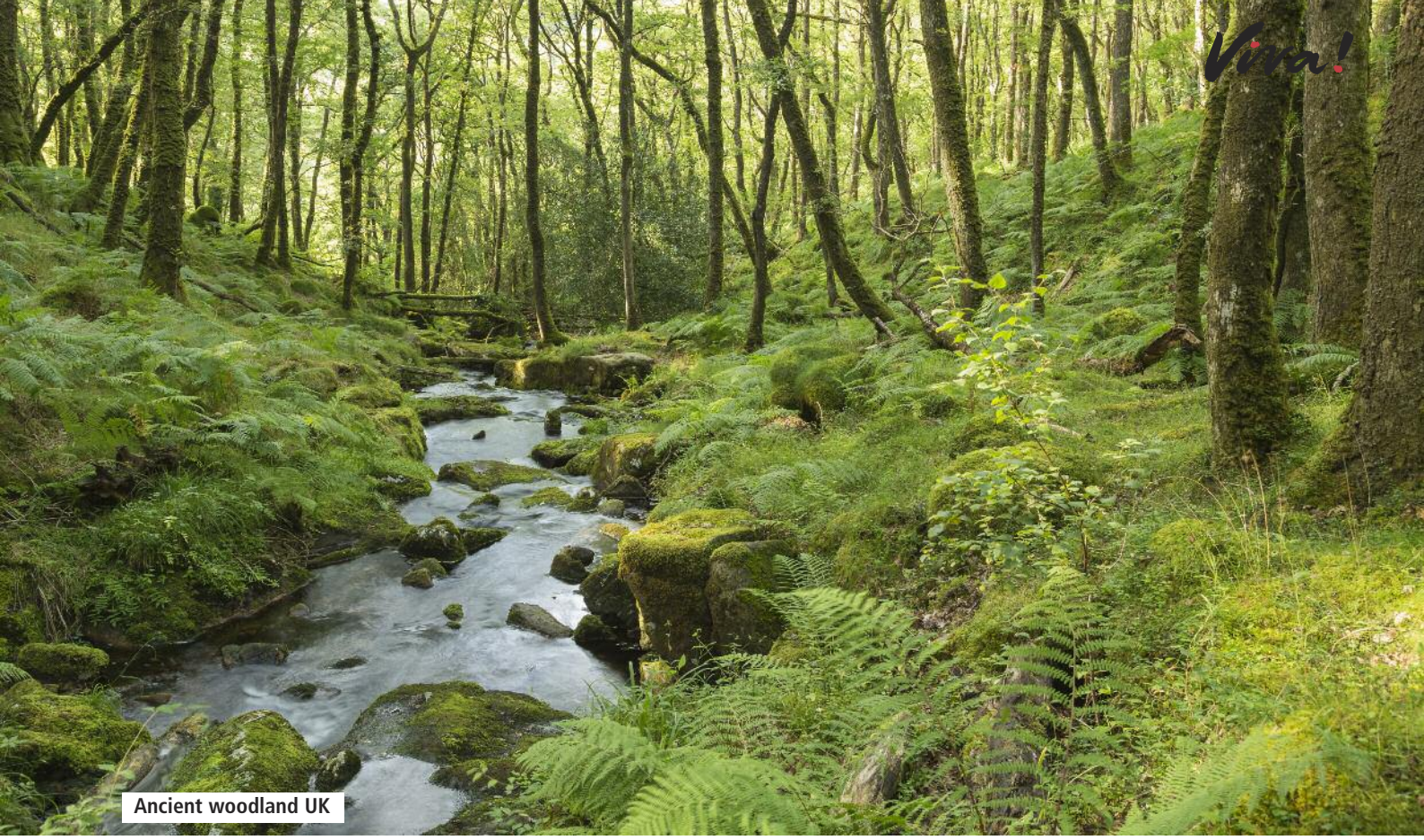
13% of freshwater and wetland species

15% of coastal species

Source: Hayhow *et al.*, 2016.

Invertebrates – heading north

Climate change is driving large-scale shifts in species distribution. A study of invertebrates in the UK, including bees, butterflies, dragonflies, grasshoppers, beetles, hoverflies, spiders and wasps, found them moving north at an average rate of almost two kilometres a year (Platts *et al.*, 2019). This is happening in other countries too. Over half of plant and animal species in temperate North


Ancient woodland UK

America have moved their ranges, moving away from the hotter edge and expanding further into the cooler edge (Weiskopf *et al*., 2020).

Mammals in the UK

In a comprehensive review of the status of mammals in Britain, the population size, range, temporal trends and prospects of Britain's 58 terrestrial mammals were assessed. The report analysed more than one-and-a-half million mammal sightings from all over Britain, many by volunteers and citizen scientists. They found that at least one in five wild mammals in Britain face a high risk of extinction within a decade and overall populations are declining (Mathews *et al*., 2018).

2 kilometres a year

Rate at which insects in the UK are spreading north because of climate change

50%

Proportion of plants and animals in North America whose range has shifted due to climate change

Sources: Platts *et al*., 2019; Weiskopf *et al*., 2020.

Most at risk, this review says, are the Scottish wildcat and black rat (which may already be extinct) and also in decline are hedgehogs and water voles. The number of hedgehogs in Britain is estimated to be around half a million, but this is very uncertain. What we do know for certain is that there are a lot less than there used to be! The same goes for water voles with an estimated 132,000 individuals left in Britain (Mathews *et al*., 2018). The report says there was only a single male greater mouse-eared bat left who was last seen living alone in a railway tunnel in West Sussex. The most numerous species was the field vole at 60 million, followed by the mole, at 41 million (Mathews *et al*., 2018). Easily outnumbered by the 1.1 billion chickens slaughtered for meat in the UK every year.

In 2020, the Red List for British Mammals was produced by the Mammal Society on behalf of Natural England, Natural Resources Wales, Scottish Natural Heritage (NatureScot) and the Joint Nature Conservation Committee. Following the same IUCN Red List criteria, it revealed that 11 of the 47 mammals native to Britain are on the brink of extinction, while a further five species are classified as near threatened (Mammal Society, 2020).

Ancient woodland in the UK depleted

Much of the environmental degradation seen globally has resulted from agricultural expansion and intensification, particularly at the expense of woodland (Foley *et al*., 2011). There has been a small increase in the amount of woodland cover in the UK over the past few decades, but the trend for ancient

woods and wildlife found there, is in steep decline (Reid *et al*., 2021).

Ancient woods are areas of woodland that have persisted since 1600 in England and Wales, and 1750 in Scotland (when maps started to be used). They may include semi natural woodland that has been planted with non-native conifers, but which retain features of their original habitat such as ground, herb and shrub layer communities and unploughed, unimproved soil (Swallow *et al*., 2020).

Just 7% of Britain's native woodlands are currently in good ecological condition

Source: Reid *et al*., 2021.

They are unique and complex communities of delicate fungi, rare mosses and special flowering plants that only thrive in ancient woodland. They are the richest and most complex terrestrial habitat in the UK – home to more threatened species than any other. Certain ecological indicator species show that a site has been wooded for a long time. These include, for example, lichens, bluebells, wild garlic and hart's tongue ferns (Woodland Trust, 2020).

Once vast, ancient woodlands now cover just 2.4 per cent of the UK land area. Around half of what remains has been cut down and replanted with non-native conifers and even more is under threat from development, overgrazing and air pollution. In their 2021 report, State of the UK's Woods and Trees, the Woodland Trust says that the climate crisis is changing the timing of seasonal events, with trees coming into leaf earlier. This means birds, such as the blue tit, are struggling to adjust their breeding times to feed on caterpillars.

"Agriculture accounts for 88% of ammonia emissions in the UK, with most emissions from livestock manures, particularly cattle and expanding poultry and pig industries"

Source: Reid *et al*., 2021.

The Woodland Trust says: "Over 1,225 ancient woods across the UK are under threat from development while during the last 21 years at least 981 have been permanently lost or damaged." The main threats, they say, include the growing number of road and rail infrastructure projects (such as HS2), local authorities and developers chopping down trees for new developments and an increase in the amount of intensive ammonia-releasing farming activities such as pig and poultry farms, which can affect ancient woodland over a wide range (Woodland Trust, 2020).

Ammonia (NH3) is a form of nitrogen air pollution affecting woods. The UK has made improvements in air quality since the 1970s, however, emissions of ammonia continue to increase. Agriculture accounts for 88 per cent of ammonia emissions in the UK, with most coming from livestock manure – particularly cattle and expanding poultry and pig industries. Nitrogen air pollution from agriculture strips trees of their layer of protective lichens and causes a fertiliser effect where grasses out-compete more delicate woodland flowers. This disrupts woodland ecosystems in ways we are only just beginning to understand (Reid *et al*., 2021).

Research shows that restoring broad-leaved woodland onto agricultural land increases biodiversity, especially earthworm species, as well as increasing the amount of carbon stored in the soil. The restoration of lost woodland ecosystems represents an opportunity to counter the negative ecological impacts of agricultural expansion and woodland fragmentation and restore biodiversity, ecosystem functions and services (Ashwood *et al*., 2019).

The impacts of sheep farming

Sheep grazing on the hillsides and uplands in the Highlands of Scotland; Black Mountains and Brecon Beacons in Wales; and the Pennines and Dartmoor in England are often portrayed as being a 'natural' part of the landscape but they are not: they are an introduced species that has put native wildlife at risk. Sheep farming is responsible for a wide range of harm to wildlife across different ecosystems. Grazing sheep trample vegetation and burrows, degrade habitats and compete for food as nutritious plants are selectively reduced or removed. Sheep graze using their front teeth to 'cut' plants creating a uniform height often just above ground level, thus undermining the land's ability to support diverse ecosystems. The ecologist, Frank Fraser Darling, used the term "wet desert" to describe how "two centuries of extractive sheep farming in the Highland hills have reduced a rich natural resource to a state of desolation" (Darling, 1955).

In hidden corners, ancient trees coated in moss cling on, supporting a range of plant and animal life – relics of an earlier time when these open landscapes were dominated by temperate rainforests. Wistman's Wood on Dartmoor is an ancient upland oak forest where the twisted moss-covered trees may be up to 400 years old

but few reach higher than 15 foot. They are protected by huge granite boulders covered by lichens and moss and where soil has accumulated, patches of acid grassland grow with heath bedstraw, tormentil and sorrel. In places protected from livestock, grazing-sensitive plants such as wood sorrel, bilberry, wood rush and bramble grow. The wood supports over 100 species of lichen including the incredibly rare Horsehair lichen (Bryoria smithii) which is thought to now be extinct in Scotland and Wales and is found at only two remaining sites on Dartmoor clinging to the bark of trees in ancient upland oak woods (Dartmoor National Park Authority, 2017).


Uplands sheep grazing


Wistman's Wood

In 2020, a study from the University of Liverpool showed how sheep grazing negatively affects the diversity of plant species of upland areas of British countryside. Their study found that if grazing stopped, some areas could take up to 60 years to recover (Marrs *et al*., 2020). The authors said: "The 'white woolly maggots' have eaten at least part of the heart out of the highlands/uplands, and it will take some time for recovery."

In 2020, the UK sheep and lamb population was 32.7 million (DEFRA, 2021). A large proportion of these can be found in upland and hill areas, some of which are designated Less Favoured Areas (LFAs) and include semi-natural 'rough grazing' and grassland. The European Union introduced the LFA system in 1975 to support farming where conditions are difficult. In England, 41 per cent of breeding sheep are found on LFAs; in Wales 63 per cent of cattle and sheep holdings are in LFAs; in Northern Ireland 80 per cent of sheep are in LFAs; and 91 per cent of breeding sheep in Scotland are in LFAs.

A 2019 Harvard study showed that there is simply no need to make food from grassland. Half (48 per cent) of all land in the UK is used for animal agriculture, either for pasture or animal feed crop production. However, by value, UK farming provides less than half of the food eaten in the UK. This study found that that if all current UK cropland was used to grow crops for human consumption instead of using it for animal feed, we could produce more than enough protein and calories for the entire UK population. This would mean that all UK grazing land (around 84,000 square kilometres) could be released from animal agriculture and restored to native forest; equal to offsetting nine years' worth of total current UK emissions (Harwatt and Hayek, 2019). We could stop wasting precious space and killing wildlife in the process.

Many farmers face financial challenges and uncertainty as the government support they rely so heavily on is to be phased out over the coming years. The Basic Payment Scheme, the biggest of the rural grants, pays farmers for the amount of land they own, regardless of its impact on the environment. In 2020-2021, the Basic Payment

accounted for more than half of the average farm income at around £28,400 (DEFRA, 2022). For many farmers, the financial help they receive from government grants and subsidies far exceeds the amount they make from farming. Farmers who graze livestock make the biggest losses, illustrating the case for ending unsustainable, uneconomic livestock farming and repurposing grazing land to protect wildlife and meet our climate goals.

Wildflower meadow with bees

The UK's Basic Payment Scheme is to be replaced with three new Environmental Land Management schemes (ELMs): The Sustainable Farming Incentive, The Local Nature Recovery scheme and The Landscape Recovery scheme. Farmers will be able to apply for grants to improve the environment, encouraging them to rewild their land. This, it is hoped, will lead to large areas of land being managed to conserve species, provide habitats for wildlife and restore health to rivers and streams. Details on how the schemes will work are still lacking and it remains to be seen how effective it will be in achieving the Government's targets; such as the protection of 30 per cent of UK land by 2030 and net zero carbon emissions by 2050.

A glimmer of hope

The Government's 2020 Environment Bill will, they claim, help to manage the impact of human activity on the environment, creating a more sustainable and resilient economy and enhancing well-being and quality of life. It will, they say, engage and empower citizens, local government and businesses to deliver environmental outcomes and create a positive legacy for future generations. The Bill introduces a mandatory requirement for biodiversity net gain in the planning system to ensure that new developments enhance biodiversity and create new green spaces for local communities to enjoy.

The Government talk about environmental harm and making polluters pay, about protecting urban trees through a consultation scheme, making producers more responsible for packaging and introducing a deposit return scheme for drinks containers (DEFRA, 2020). Nowhere on their policy statement do they mention animal agriculture and the need to reduce our intake of animal foods! Given the central role animal agriculture plays in driving the loss of wildlife, this incredible oversight or omission inspires little, if any, confidence in the Government's commitment to protecting biodiversity in the UK and wider afield.

A new interim non-departmental public body, the Office for Environmental Protection (OEP) was established in November 2021 as an independent, domestic watchdog set up to "protect and improve the environment by holding government and public authorities to account". It remains to be seen if this body has any will or ability to effect meaningful change.

Attempts at setting targets to tackle nature loss in the UK and further afield have so far failed because environmental protection has been insufficient, restoration has been inadequate and the implementation and enforcement of legislation has been lacking. In 2019, Karmenu Vella, European Commissioner for Environment, Maritime Affairs and Fisheries in the European Commission, delivered a powerful speech in which he said: "We are not on track to reach our targets. The pressures are enormous, and they continue to grow. The problem, quite simply, is the way that we live. The way we produce, the way we consume, the way that we trade. What will it take to change? When will we stop giving to the environment with one hand, and taking away with the other?" (European Commission, 2019).

Biodiversity loss is directly related to the expansion of animal agriculture and the associated deforestation, overgrazing, pollution and degradation of land. In addition, livestock production also leads to substantial emissions of nitrogen in various forms (ammonia and nitrates), which in turn lead to losses of both land and aquatic (including marine) biodiversity. The only way to ensure you are not contributing to the problem is to go vegan.

Agrobiodiversity

"Three quarters of the world's food is generated from just 12 plant and five animal species."

(FAO, 2004).

Agricultural biodiversity is the variety of animals, plants and microorganisms used directly or indirectly for food and agriculture (Committee on World Food Security, 2017). In the same way that wild animals and plants are disappearing, the number of different animal and plant species that humans eat has fallen dramatically over the last 50 years. Variety may be the spice of life, but it is also the spice of food and we are clearly missing out.

Varieties of bananas

In India, there are more than a thousand varieties of mango, yet just a handful are commonly grown. The Tommy Atkins is one of the most commonly sold mangos in the world as it has an extremely long shelf-life. However, there are many others including ones that taste of coconut or pineapple, which most people will never taste.

For bananas, just one variety, the Cavendish, accounts for 47 per cent of worldwide production and 99 per cent of the commercial export sale to developed countries, despite there being over 500 varieties including the Blue Java – the ice cream banana, so named for its blue skin and creamy, ice cream-like texture; the Macabu, which is black when fully ripe with a sweet pulp; the Niño, a mild and finger-sized fruit and the Burro banana, which has squared sides and a lemon flavour when ripe. It's disappointing that we limit ourselves to just one type of banana when so many different and exciting varieties exist.

The same story of selective breeding and mass production is shared by most other crops we consume nowadays and estimates suggest that only 30 of the 7,000 or so edible plant species are being used to feed the world's population (Committee on World Food Security, 2017). Most land used to grow cereals and grains is only farmed with wheat, maize or rice (Committee on World Food Security, 2017). We seem hell-bent on creating a world dominated by just a few species of animals and plants – a situation any biologist would recognise as precarious!

Where you have diversity, there will be a range of survival strategies and abilities. Some species, for example, may be susceptible to a particular disease that others are able to withstand. Ignoring that is called 'putting all your eggs in one basket' – diversity is an insurance.

75% of the world's food is generated from just 12 plant & 5 animal species

Source: FAO, 2004.

In Ireland, in the mid-1800s, the widespread dependency on just one single crop – the potato – plus the lack of genetic variability among the potato plants (a monoculture), were two reasons why the emergence of potato blight had such a devastating effect. It's estimated that about one million people died either from starvation or disease and a million more emigrated.

We seem to have learnt nothing from the lessons of history as plants and animals are still selected for

uniformity and suitability to intensive farming methods, such that global food production is now dominated by just a handful of species farmed in huge monocultures and mega farms.

There are more pigs than people in Denmark and there are concerns that other countries may soon follow. The Ministry of Environment in Spain released figures in 2018 saying that around 50 million pigs were slaughtered in the country the previous year, more than Spain's 46.5 million population. Many of these pigs would have been slaughtered shortly after they were born. This led to concerns that Spain's pig population may soon surpass its human population.

> "Globally, local varieties and breeds of domesticated plants and animals are disappearing. This loss of diversity, including genetic diversity, poses a serious risk to global food security by undermining the resilience of many agricultural systems to threats such as pests, pathogens and climate change."
>
> IPBES, 2019.

When you consider how much of life on Earth is made up of individual species, there are a number of different ways to quantify the contribution of each. You can, for example, count the number of species, population size or the number of individuals. But these metrics can make it difficult to compare between groups: small organisms may have a large population but still account for a very small percentage of Earth's organic matter. For a meaningful comparison, some scientists quantify life using biomass (weight).

In terms of biomass, over 70 per cent of all the world's birds are chickens and other domesticated poultry, with wild birds making up the remaining 30 per cent (Bar-On *et al*., 2018). In terms of numbers, there are 24 billion chickens and less than eight billion people in the world – so more than three birds for every single person on the planet. Whichever way you look at it, domesticated poultry are massively over-represented among the world's bird population.

It's a similar scenario for mammals. If you weighed the global cattle population, that biomass would be greater than the weight of all the world's humans (Bailey *et al*., 2014). Again, by weight, 60 per cent of the mammals on Earth are livestock, 36 per cent are humans and only four per cent are wild (Bar-On *et al*., 2018).

Such massive livestock populations have profound consequences for biodiversity for several reasons. These include their contribution to climate change, deforestation, change of land use, overgrazing, degradation of grasslands and desertification (Bailey *et al*., 2014). The only clear solution to this problem is to stop eating meat, fish, eggs and dairy and go vegan.

Of all the mammals on Earth

Of all the birds on Earth

Climate change

"While climate change has not been the dominant driver of biodiversity loss to date in most parts of the world, it is projected to become as or more important than the other drivers of change."

Sir Robert Watson, IPBES Chair and former chair of the UN's Intergovernmental Panel on Climate Change.

Rising global temperatures – caused by increasing atmospheric levels of the greenhouse gases carbon dioxide, methane and nitrous oxide – pose numerous threats to wildlife. Animal agriculture produces an estimated 7.1 gigatonnes of carbon dioxide equivalents per year – representing 14.5 per cent of human-induced greenhouse gas emissions (Gerber *et al*., 2013), this is more than all the world's transport put together (IPCC, 2014).

Australian bush fires

Many scientists now believe that livestock emissions (especially methane), are probably much higher than this because breeding and feeding methods have changed, meaning that current estimates are based on out-of-date information (BMC, 2017). One study suggests that by 2050, emissions from meat and milk production could be 21 per cent higher than previously predicted (Hayek and Miller, 2021).

The principal cause of biodiversity loss at the moment is the loss of habitat due to a wide range of human-related causes but with animal agriculture at the heart of the problem. However, over the next few decades, climate change (which of course also has animal agriculture at the heart of it) is expected to push even more species over the brink – we are already seeing the effects.

Many plants and animals are moving into new geographical areas as their current habitats have become too hot. There are fears that the entire Amazon rainforest could be at serious risk. In the oceans, some organisms have moved hundreds of kilometres, but for others, unable to move, like coral reefs, the outlook is bleak and many have already died. In polar regions, the loss of sea ice is proving to be catastrophic for polar bears and other animals.

Global warming increases the risk of extreme weather events like hurricanes, cyclones and flash floods. It is also increasing the duration, frequency and intensity of heatwaves, which can have the effect of increasing the risk of fires. Leading climate scientists say there is an unequivocal link between Australia's recent catastrophic bushfire season and climate change. Rising temperatures boosted the risk of the hot, dry weather (that is likely to have caused the recent bushfires in Australia) by at least 30 per cent, scientists say (van Oldenborgh *et al*., 2020).

Fire and ice

Wildfires are a natural phenomenon and some tree species have adapted to tolerate fire. In fact, fire acts favourably for a small number of species such as eucalyptus. However, the increasing severity of fires in Australia and California suggests human activity is making them worse and more dangerous. A report compiled by scientists from the University of Sydney, University of New South Wales, University of Newcastle, Charles Sturt University and BirdLife Australia and commissioned by WWF-Australia, found that Australia's devastating bushfires in 2019 and 2020 killed or displaced nearly three billion animals – far more than

previously thought. They found that almost two-and-a-half billion reptiles were impacted, along with 180 million birds, 143 million mammals and 51 million frogs (WWF, 2020a).

WWF-Australia CEO Dermot O'Gorman said: "It's hard to think of another event anywhere in the world in living memory that has killed or displaced so many animals. This ranks as one of the worst wildlife disasters in modern history." O'Gorman added that with extreme fires becoming more frequent due to climate change, the report's findings "give other countries a window into the future of mega fires and their devastating impact on wildlife" (WWF, 2020a).

One of the lead researchers on this study, Professor Chris Dickman, from the University of Sydney, says the research shows that mega fires are changing the environment and depleting native biodiversity and change is necessary. Dickman says: "How quickly can we decarbonise? How quickly can we stop our manic land clearing? We land clear at a rate that's one of the highest in the world" (WWF, 2020a).

Less than 5,000 miles away, emperor penguins in Antarctica are feeling the heat too. They need solid sea ice for most of the year while they find mates, breed and raise their chicks – but the ice is melting. One study of emperor penguins in Antarctica suggests that if emissions keep rising, the birds could die out soon after 2100. Stephanie Jenouvrier, from the Woods Hole Oceanographic Institution in Massachusetts, says that the future of these birds hinges on international climate efforts rather than their ability to adapt and move. "Penguins are this indicator species, this canary in the coal mine, they are warning us of the future effect of climate. The big message is we need to listen to the penguins, and implement policies to meet the Paris agreement's objective, and we need to do that now" says Jenouvrier (Vaughan, 2019a).

At the northernmost part of the Earth, the Arctic is experiencing similar, if not worse, problems. In the first six months of 2020, unusually high temperatures were recorded in this polar region, including a record-breaking 38°C in the Siberian town Verkhoyansk on 20 June (WWA, 2020). The increased and prolonged heat has led to Arctic wildfires blazing in northern forests and underground peat emitting the equivalent of 56 megatonnes of carbon dioxide in June 2020 (Copernicus Atmosphere Monitoring Service, 2020). The smoke from the wildfires is moving across Alaska, Canada and could eventually reach Greenland.

Scientists are concerned that the air pollution from the fires may exacerbate respiratory problems in Russia, a country hit badly by Covid (Vaughan, 2020). Some of these underground "zombie fires" may have been smouldering since the previous year – this does not bode well for future years.

According to scientists, temperatures in the Arctic Circle were around 8°C above average for the first half of 2020 and 10°C above average in June. The effects have been widespread: the sea ice, which polar bears rely on to hunt their prey, has shrunk; fish are swimming deeper in the oceans looking for cooler water and a huge oil spill resulted from a container collapsing as the permafrost it sat on thawed in the heat (Vaughan, 2020). Although heatwaves do occur naturally, this one, scientists say, would have been almost impossible without the greenhouse gases human activity has pumped into the atmosphere. Research suggests this heatwave is thought to have been made at least 600 times more likely by climate change (WWA, 2020).

In other areas of the Artic, in Alaska and north-west Canada, the weather has been unusually wet and cold recently, with increased rainfall contributing to the loss of permafrost. This adds another layer of concern because as ice, which reflects sunlight, melts, it is replaced with darker water, which absorbs sunlight, thus contributing further to global warming.

Recent years have been disastrous for the Arctic, the fallout from which will have global impacts. However, according to scientists, there is still time to act. Associate Professor Merritt R. Turetsky, from the University of Colorado in Boulder, told the *New Scientist*: "To me, this is a warning, a cry from the Arctic. This is our early beacon sign of what's to come in terms of rapid climate change around the world. We can still stave off the worst consequences of climate change, but our window to do that is small" (Vaughan, 2020).

Limiting further warming is crucial for the survival of wildlife and humanity. If the planet keeps warming, entire habitats could disappear along with all the species that inhabit them. The impact on humanity could be catastrophic. Going vegan is the single most effective way to reduce your greenhouse gas emissions.

Time for action

"The present generations have the responsibility to bequeath to future generations a planet that is not irreversibly damaged by human activity. Our local, indigenous and scientific knowledge are proving that we have solutions and so no more excuses: we must live on Earth differently."

Audrey Azoulay, Director-General, United Nations Educational, Scientific and Cultural Organization (UNESCO).

Children enjoying nature

We love walking in forests and mountains, exploring beaches and swimming in the sea. Seeing wild animals excites us; people gather on the shoreline pointing out to sea when a pod of dolphins is spotted. Most of us know the thrill of seeing a hedgehog, a fox, or if you are very lucky, a badger, sniffing about in the garden. Even listening to simple birdsong in a quiet moment brings pleasure. We love nature, but most people don't realise how much it sustains us in many more ways than just bringing us pleasure.

The rich variety of life on Earth provides us with the food we eat, the water we drink and the air we breathe. We are taking it for granted that the natural world will just take all the abuse we throw at it and somehow manage to cope. It is not coping; it is literally dying around us. For decades scientists have been warning that human activity is pushing life on our planet towards a sixth mass extinction – now we are there. Natural ecosystems are degrading at a rate unprecedented in human history and our insatiable hunger for meat, fish, dairy and eggs is one of the most powerful negative forces driving this destruction.

What you can do

On an individual level, you can help combat the insect apocalypse by making your garden more wildlife friendly, mowing the lawn less often, creating "bug hubs", planting wildflowers and vegetable gardens, letting weeds grow and not using pesticides. You can plant more nectar-rich plants like alliums, chives, foxgloves, crocuses, sunflowers and lavender to attract pollinators. You can make a bee hotel…

But animal agriculture is the bigger issue and large-scale change is needed – urgently. The devastating impact livestock farming is having on the world's rich biodiversity can be stopped through the widespread adoption of a vegan diet. Joseph Poore, researcher at the University of Oxford, says: "A vegan diet is probably the single biggest way to reduce your impact on planet Earth, not just greenhouse gases, but global acidification, eutrophication, land use and water use" (Carrington, 2018). Poore was so convinced by the research that he adopted a vegan diet himself. Poore's voice is just one of many; an increasing number of scientists are joining the ranks calling for the widespread adoption of a vegan diet to halt climate change and loss of biodiversity.

The entire fabric of life on Earth has evolved and developed naturally over many millions of years. The vital contributions made by nature to humanity affect virtually all aspects of human existence and our reliance on nature is widely recognised but is not reflected in government policies. A landmark UN biodiversity summit has been postponed three times because of the Covid-19 pandemic. The delay meant that at the start of 2022 there were no global goals for stopping biodiversity loss!

Governments simply cannot ignore the problem any longer. They are already gambling with very high stakes. Ignoring the devastating impact livestock farming is having on biodiversity has been likened by some scientists to playing a game of ecological roulette. Government support for a radical change in how we eat is long-overdue and the need for action has never been so urgent.

Professor Sandra Díaz, who co-chaired the assessment on which the landmark UN report on biodiversity was based said: "The diversity within species, between species and of ecosystems, as well as many fundamental contributions we derive from nature, are declining fast, although we still have the means to ensure a sustainable future for people and the planet." It's not too late to make a difference, but only if we start now at every level from local to global.
In his recent speech to the European Commission, Karmenu Vella said: "We need to give more support. We need to be bolder in numerous ways. Harmful subsidies must become a thing of the past. The only farming and fishing activities to receive support should be fully compatible with biodiversity protection. It's time to favour practices that produce healthy food without poisoning insects, without destroying landscapes, or damaging healthy soils" (European Commission, 2019).

There are a range of options for achieving sustainability in agriculture, forestry, marine systems and other sectors, according to scientists. Priorities, they say, must focus on increasing awareness of the importance of biodiversity and conservation. Sustainable production and consumption must be prioritised. Subsidies and incentives will need reforming and deforestation, poaching and trafficking must stop. Geographical areas of importance should be protected and pressures on vulnerable ecosystems must be reduced and recovery plans made for species that have declined. The IPBES report says: "Nature can be conserved, restored and used sustainably while simultaneously meeting other global societal goals through urgent and concerted efforts fostering transformative change" (IPBES, 2019).

In their 2020 report, *Approaches to sustainable agriculture*, the IUCN says: "Agriculture is a fundamental human activity that intrinsically depends on nature and at the same time poses a threat to it. Thus, sustainability has emerged as a necessity in future agricultural policy and practice" (Ober and Arroyo Schnell, 2020).

Many people are reducing their meat intake over concern for animal welfare, the environment and their health. The meat industry is beginning to feel the pinch and the value of some giant meat-producing companies has plummeted, as investors are looking to support more sustainable protein products like plant-based foods and cultured "lab meat". So, while the scale of the problem is immense, the tide is beginning to turn.

The Plant Based Treaty

As a companion to the Paris Agreement, the Plant Based Treaty is a landmark international treaty and first of its kind to put food systems at the heart of combating the climate crisis. The Treaty aims to halt the widespread degradation of critical ecosystems caused by animal agriculture, to promote a shift to more healthy, sustainable plant-based diets and to actively reverse damage done to planetary functions, ecosystem services and biodiversity.

In evolutionary terms, *Homo sapiens* were late to the party, but our arrival has certainly been felt from one side of the globe to the other. With a global population soon to reach eight billion, our influence has spread everywhere, with dire consequences for many of the other species with whom we share the planet. Governments have expressed concern about biodiversity loss – but we now need action rather than targets and empty promises. We know what needs to be done – what is lacking is the political will to adopt a new approach and a genuine commitment to pursue it.

"Averting a dramatic decay of biodiversity and the subsequent loss of ecosystem services is still possible through intensified conservation efforts, but that window of opportunity is rapidly closing" (Ceballos *et al*., 2015). It is time to stand up for nature and go vegan today!

For more information on how a new way of farming could restore ecosystems, wildlife and biodiversity, improve food security and food self-sufficiency and alleviate sector uncertainty, see viva.org.uk/planet/the-solutions.

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One million animal and plant species are at risk of extinction – humans included! Without biodiversity, there is no future for humanity. This report explains why so many species are living under threat, outlines why animal agriculture lies at the heart of the problem and spells out the consequences of inaction. The huge global demand for meat, fish, eggs and dairy has led us into the world's sixth mass extinction and we are losing species at a thousand times the natural rate. Eat a ham sandwich and you kill a Sumatran elephant; eat a steak and you destroy a lemur in Madagascar; eat a chicken and you wipe out an Amazonian parrot – it's that stark! From magnificent African forest elephants and mountain gorillas to humble British hedgehogs and reclusive water voles, hooded seals of the North and microscopic algae living in the oceans – that produce half the world's oxygen – all are threatened by livestock farming and aquaculture. More than half of the world's marine species face extinction by the end of this century. Wildfires are blazing in the Arctic and zoonotic diseases are jumping from animals to humans at an ever-increasing rate. There is still hope – just! Find out what you can do to save the planet in this timely report.

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