Our climate's secret ally:

Uncovering the story of nature in the IPCC Sixth Assessment Report

November 2022

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FOREWORD

We will not halt climate change if we allow the crisis in nature to continue unabated. By the same token, if we are unable to limit warming to 1.5°C, climate change is likely to become the dominant cause of biodiversity loss in the coming decades. As the interlinkages between the climate system and nature on land, freshwater systems and in the oceans become ever clearer, so too does the urgent need to bring together our efforts to stop and reverse nature loss and decarbonise the global economy.

These interlinkages are highlighted throughout the work of the Intergovernmental Panel on Climate Change (IPCC), the UN body responsible for explaining the latest climate science to the world's policymakers. Its Sixth Assessment Report makes clear both that climate change is negatively impacting nature, but also that healthy nature is an ally that helps prevent climate breakdown and make us more resilient to a warming planet.

The science shows that Earth's natural systems play a central role in regulating the climate – and in protecting us from the worst consequences of our actions. The world's oceans, plants, animals and soils have absorbed 54% of man-made greenhouse gas emissions of the past 10 years. Critical ecosystems, such as wetlands, mangroves and coral reefs, help to shield us from the worsening hazards of extreme weather and sea-level rise.

These natural systems are under threat and have their own limits. Rising temperatures and changing rainfall patterns are altering the ranges of animals and plants as they try to track their preferred climate, disrupting food webs and breeding patterns. Extreme weather events such as drought, wildfires and marine heatwaves, can destroy entire ecosystems and cause mass mortalities.

Beyond certain thresholds, some of the impacts become irreversible. The world's tropical coral reefs face near-complete destruction even at 1.5°C of global warming. Once areas of rainforest become too degraded and fragmented, they can tip permanently into savannah. Sea-level rise will destroy many unique, biodiversity-rich low-lying coastal and river delta areas forever.

The risks threaten people as well as nature. Human societies, culture and our economy are fundamentally dependent upon nature – for food and water security, for air quality, for protection against disease, for energy, the list goes on. Many Indigenous Peoples and local communities depend directly on ecosystems for their survival.

This report draws upon the IPCC's work to highlight the interlinked emergencies of human-induced climate change and biodiversity loss, threatening the well-being of current and future generations and to make the case for better integrating nature into our response to the climate crisis.

It is clear that, without harnessing the ability of nature to store carbon and help regulate the climate, it will be impossible to meet the goals of the Paris Agreement to limit global warming to 1.5°C above pre-industrial levels and avoid the worst risks of climate change. And without the protections healthy nature provides from climate hazards, more people will be at greater risk. Conserving 30 to 50% of land, freshwater and oceans areas could help safeguard nature, help protect the climate, and benefit people. Nature-based solutions, which protect and restore natural ecosystems, can both address climate change while supporting people and nature. Nature is a secret ally, but also untapped potential to help address the climate crisis.

Nature can't do all the work alone. We must rapidly and equitably cut greenhouse gas emissions, with all sectors and all countries needing to contribute. We need to provide the financial resources to help the most vulnerable adapt.

By employing all of these actions we must change our current trajectory from around 2.5°C warming by the end of this century[1]. There is no space for delays – overshooting 1.5°C poses terrible climate change risks on both people and nature.

We hope this report amplifies the important work of the IPCC by spotlighting the story of nature and climate change – including what it is doing for us already in the fight against climate change and how this is dangerously at risk. Nature can continue to help us in the fight against climate change, but only if we help it first.




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1 2022 NDC Synthesis Report (UNFCCC)

INTRODUCTION

The rapid biodiversity decline and ecosystem degradation that we are witnessing today shows that we have for too long taken nature for granted. ***Nature is a critical and undervalued ally in the fight against climate change,*** *helping us both slow global warming and adapt to the climate impacts that are affecting communities around the world.*

This report distils the key scientific findings from the three Working Group contributions to the Sixth Assessment Report (AR6) of the IPCC: *AR6 Climate Change 2021: The Physical Science Basis* (Working Group I); *AR6 Climate Change 2022: Impacts, Adaptation and Vulnerability* (Working Group II); and *AR6 Climate Change 2022: Mitigation of Climate Change* (Working Group III).

The Sixth Assessment Report represents the latest and most comprehensive climate science, drawing from the work of thousands of experts and peer-reviewed studies from around the globe. It includes significant scientific advances in the attribution of climate change impacts; better projections for specific regions of the world; and the latest understanding of the risks of tipping points such as the collapse of ice caps or Amazon rainforest dieback.

Our Climate's Secret Ally, specifically draws attention to the fundamental connections between nature and climate, as told in the Sixth Assessment Report. By 'nature', we mean the entire living world that encompasses natural ecosystems and managed lands (including sustainable agricultural systems), and the biodiversity – animals, plants, all living things, and their interrelationships in those habitats.

Biodiversity provides services that are essential for human health and livelihoods, such as clean air, drinkable water, productive oceans and fertile soils for growing food. With biodiversity loss, we not only lose nature, we also lose some of our best defences against climate change. Natural ecosystems help store carbon and protect humankind from climate impacts.

The increasing temperatures and climate-change related extreme weather causes biodiversity changes and loss of ecosystem services, which subsequently leads to more climate change, which causes more biodiversity loss. The Sixth Assessment makes it clear that the dual climate and biodiversity crises are two sides of the same coin and cannot be addressed independently.

Section 1, *Current state of the climate*, summarises the observed changes in the Earth's climate across all regions of the world, with many of those being unprecedented in thousands of years.

Section 2, *Nature: a secret ally in the fight against climate change,* highlights how nature offers significant yet untapped potential to reduce climate risks and to improve people's livelihoods. While nature is a vital ally in buffering the impacts of global warming, this has limits. For example, natural carbon sinks won't work as well in a warmer world.

Section 3, *Nature under threat from climate change,* describes the changes that the global climate emergency has brought to all life forms on every continent, from the loss of species to the compromised ability of ecosystems to function properly and provide vital services.

Section 4, *Working with nature as a climate solution,* demonstrates how we can support nature's work in climate regulation and mitigation by safeguarding and restoring healthy, thriving ecosystems and doing everything we can to reduce emissions. Nature-based solutions harness the power of nature to address climate change, but if we do not also take the steps to cut fossil emissions immediately and aggressively, many of the options that we can rely on in nature to reduce the force of climate change will simply not be available in the future.

In addition to summarising the outputs of the IPCC Sixth Assessment, WWF includes **four case studies** that draw from illustrative examples included in the IPCC report and WWF's work on the ground, illuminating the diverse aspects of the interdependence of climate, biodiversity, and people.

Lastly, WWF calls on governments, with **a series of recommendations**, to ensure that climate responses appropriately deliver the right outcomes on nature, climate and people. Specifically, governments must show leadership and political will to cut global greenhouse gas emissions consistent with limiting global warming to 1.5°C. At the same time, governments must protect, manage, restore and create healthy natural ecosystems, a non-negotiable action if we want to adapt to and slow climate change.

KEY MESSAGES

NATURE IS OUR MITIGATION ALLY

Nature has slowed global warming, it has absorbed 54% of human-related carbon dioxide emissions over the past 10 years. This has saved humanity from much more severe impacts from climate change. 31% is removed by the terrestrial ecosystems, including in plants, animals and soils. The other 23% is taken up by the ocean; while this slows global warming it leads to acidification which has disastrous consequences for many marine ecosystems.

NATURE IS OUR ADAPTATION AND RESILIENCE ALLY

Nature offers protection from climate change impacts. In addition to slowing global warming, healthy ecosystems can increase resilience and keep people safer from climate impacts – for example coral reefs, wetlands and mangroves provide some protection from storm surges, and forests can soak up excess rainwater, preventing run-offs, landslides and damage from flooding.

WE ARE LOSING NATURE AS OUR ALLY

Global warming poses huge risks to nature. Global warming of 1.1°C is already causing dangerous and widespread disruption in nature. As polluting human activities emit more and more carbon dioxide into the atmosphere, nature's capacity to absorb carbon is weakening, and degraded ecosystems will accelerate the release of their stored carbon. Healthy ecosystems are more able to protect against climate impacts.

Nature has adapted in response to climate change. Nature has some capacity to adapt to temperature rise and rainfall changes. Some plants and animals are able to disperse fast enough to shift geographical ranges to track their preferred climate conditions (though this encroachment can have negative knock-on effects on nearby ecosystems), and some are changing physiology or altering their life cycles in response.

Some natural systems are being pushed beyond their limits by the constant pressure of multiple and compounding threats from climate change, including worsening extreme events, on top of non-climate-related threats like pollution, over-exploitation, and ecosystem conversion. Impacts on nature worsen as global warming worsens, until ecosystems can no longer function, and no longer provide climate services.

The impacts of global warming on natural systems could be long lasting or permanent. The likelihood that land, freshwater, and ocean ecosystems will be irreversibly damaged or lost grows with every fraction of a degree of global warming, especially above 1.5°C. This is true even if global warming overshoots 1.5°C for several decades and returns to that level by the end of the century. This is one important reason to make all efforts to limit global warming to 1.5°C with no or limited overshoot.

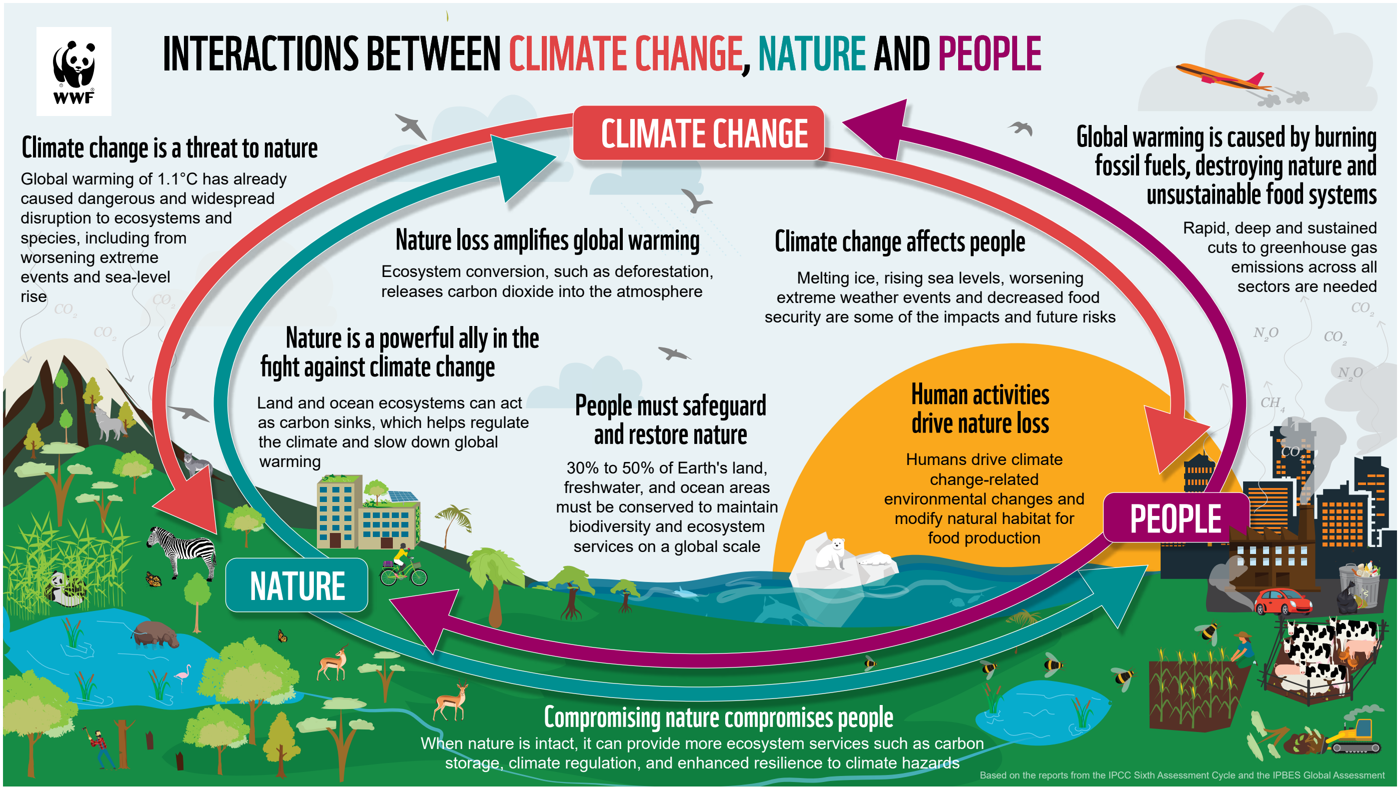
PEOPLE AND NATURE MUST BE ALLIES FOR A 1.5°C PATHWAY

If we are to continue to adapt to and slow climate change we must safeguard and restore nature. This is part of every climate scenario in line with the Paris Agreement's 1.5°C global warming threshold. Enhancing and restoring healthy ecosystems, can help increase mitigation and resilience and reduce some of the projected losses and damages.

Nature is an important part of the solution but cannot do it all alone. For example, in 2019, 64% of global greenhouse gas emissions were from fossil fuels (coal, oil and gas) and industry. Investing in nature alone won't be sufficient and is not a substitute for economy-wide decarbonisation leading to rapid, deep and sustained cuts to emissions.

NATURE COULD CONTINUE TO BE OUR ALLY IF WE PROVIDE THE RIGHT SUPPORT

There is more that nature can do for us. Climate action and sustainable development are interdependent, and climate resilient development[2] is possible when this interdependence is leveraged by pursuing them in an integrated way. Nature can continue to help us but only if we help it first. Safeguarding and restoring biodiversity and ecosystems is part of climate resilient development in enhancing ecological health and human well-being.



2 Climate resilient development is the process of implementing greenhouse gas mitigation and adaptation measures to support sustainable development.

CURRENT STATE OF THE CLIMATE

The climate crisis is affecting every corner of our planet. *It influences land, air and ocean in profound ways, reshaping landscapes and seascapes, displacing people and wild animals, and disrupting natural ecosystems.*

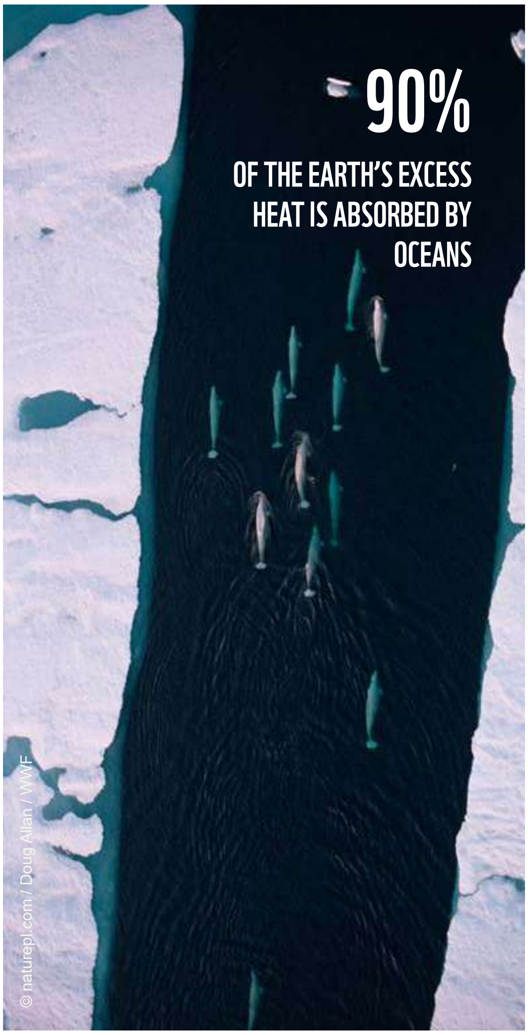
The planet has already warmed by an average of about 1.1°C above pre-industrial levels. Each of the last four decades has broken the record for warmest temperatures. The recent changes to the climate are happening fast and at a scale never seen before over thousands to millions of years. Global surface temperatures have increased faster since 1970 than any time in the last 2,000 years. In the next 20 years, **global warming** will reach or exceed 1.5°C.

Human activities that emit **greenhouse gas emissions** are unequivocally driving the rapid, widespread and intensifying changes in the climate. Global net greenhouse gas emissions had risen to 59 billion tonnes[3] in 2019. The burning of fossil fuels – coal, oil and gas – was responsible for 86% of all human-induced carbon dioxide (CO_2) emissions in the most recent decade while the destruction of natural ecosystems to support agriculture and other human uses has contributed to the remaining CO_2 building up in the atmosphere. Humanity has emitted about 2,400 billion tonnes of CO_2 since 1850. CO_2 levels in the atmosphere are now higher than at any point in the last two million years, and the rate of increase in the last century is at least 10 times faster than any other time during the last 800,000 years.

The overheating of the planet has far-reaching consequences for the natural systems. Glaciers are retreating faster than they have for millennia. Both the Greenland and Antarctica ice sheets have been melting for at least the last 30 years, recording the highest **ice loss** in the last decade.

The added water from the melting ice sheets and glaciers and the expansion of seawater as it warms have caused sea level to rise by 20 cm on average since the beginning of the last century. Sea level has risen faster over the last hundred years than during any century in the last 3,000 years. The rate of **sea level rise** has increased to about 3.7 mm per year between 2006 and 2018. Emissions cuts will substantially reduce further sea level rise, but some increase is unavoidable. Even if warming is limited to 1.5°C, sea levels are expected to rise a further 28 to 55 cm by 2100 compared to the 1995-2014 average, and continue to rise for hundreds to thousands of years.

3 This is in *carbon dioxide equivalent* using Global Warming Potential with a time horizon of 100 years. On this basis, 64% of the 59 billion tonnes was CO_2 from fossil fuel and industry; 11% net CO_2 from land use, land-use change, forestry, 18% methane (CH_4), 4% nitrous oxide (N_2O), and 2% fluorinated gases.



A warming climate also influences wind patterns, how storms form and how they travel. Warming increases condensation rates, which in turn releases additional heat that can make **storms and rainfall** worse. By 2100, global annual precipitation on land is projected to increase on average by 2.4% if we keep emissions low and by 8.3% in a high-emissions scenario.

Today, **extreme events** made worse by climate change such as heatwaves, storms, heavy rainfall and drought are hurting people and nature everywhere in the world. In low-lying coastal areas, rising sea levels lead to more frequent and severe flooding while elsewhere, more intense rain contributes to floods that threaten lives and damage infrastructure. Between 1970 to 2019, 44% of all disasters were flood-related.

The warming planet brings more severe and frequent **tropical cyclones** that affect millions of people every year. In March 2019, Cyclone Idai was the deadliest storm on record to strike the African continent, causing massive housing, water supply, drainage and sanitation destruction.

Rising global temperatures are intensifying **the global water cycle**, resulting in very dry and very wet seasons, leading to reduced and unpredictable freshwater availability in many places. The water cycle describes the continuous, naturally occurring movement of water on Earth. It evaporates, rises into the atmosphere, cools and condenses into rain or snow and falls again to the surface, replenishing soil moisture, recharging groundwater, and supporting river flows.

Terrestrial **freshwater** represents less than 2% of all water on Earth and is one of the most essential natural resources on the planet. Around four billion people are already experiencing severe freshwater scarcity for at least one month of the year, with half a billion people in the world facing severe water scarcity all year round.

Hot and dry conditions fuelled by increased temperatures and the lack of rain create severe **droughts**. Soils and streams dry out and plants can't cope with the stress of prolonged periods without water. As warming decreases snowpack, drought will become worse in regions such as in south-western South America, where people and nature rely on snowmelt as a water resource.

Hot and dry conditions also create hotbeds for destructive **wildfires**. For example the area of Western North America's forest destruction by fire has doubled between 1984 to 2015 because of climate change, greater than the size of Switzerland. During the 2019/2020 summer, bushfires in Australia killed between 0.5 and 1.5 billion wild animals and burned 97,000 km^2 of vegetation, which provided habitat for 832 species of native vertebrates.

While no region on Earth is escaping the impacts of climate change, the **Arctic** is changing at a record pace. It has warmed at more than twice the global rate in the last 50 years, causing sea ice – the foundation of Arctic life – to shrink, changing the face and reality of the region. Summer Arctic sea ice cover has decreased about 40% since 1979, and is now smaller than at any time in at least 1,000 years. The Arctic Ocean is expected to be practically sea ice free in September at least once before 2050 as global warming continues.

The **oceans**, covering 70% of the planet, are warming up rapidly. Since 1970, the ocean has absorbed more than 90% of the excess heat added to the Earth's climate. The ocean's surface layer, home to a high diversity of marine life, takes most of this heat. As a result, the top 700 metres of the global ocean have warmed by 0.88°C on average since 1900.

Marine heat waves - the oceanic version of the sweltering heat events that ripple across land - have doubled in frequency since the 1980s. They have become more intense and last longer. During these hot events, temperatures near the surface of the ocean can spike up to several degrees above the average, with devastating impacts for marine life.

CO_2 emissions have also led to **ocean acidification** and reduced oxygen levels in many parts of the upper ocean since the mid-20th century. Warming reduces the ventilation of the ocean and solubility of oxygen, which in turn leads to deoxygenation. Between 1970 and 2010 the ocean has lost up to 3.3% of its dissolved oxygen in the upper 1,000m depth. The equatorial and North Pacific, the Southern Ocean, and the South Atlantic have shown the greatest oxygen loss.

Disruptive and dangerous weather events will only get **worse with every increment of warming**. Right now, extreme heat waves are happening every decade. With 1.5°C warming, they will occur every five years; with 2°C, every three to five years; and with 4°C, once every 15 months. Extreme rainfall events increase by 7% for each additional 1°C of global warming.

The IPCC has assessed the climate response to **five different scenarios** of greenhouse gas emissions and has found that compared to the period between 1850 and 1900, end-of-century global temperatures will be higher by 1.0°C to 1.8°C if we keep greenhouse gas emissions very low, but can go up to 5.7°C if greenhouse gas emissions continue to be very high. The last time global surface temperature was ever above 2.5°C higher was 3 million years ago, which places humanity in a dangerous uncharted territory.

CLIMATE MODELS AND SCENARIOS

Possible futures are projected using climate models running different scenarios. Some scenarios look at what happens if a lot of action is taken globally to cut greenhouse gas emissions. In other scenarios, emissions, and consequently temperatures, continue to rise. Global warming is projected to be broadly similar for the next few years, but after the 2050s the climate models show very different levels of warming, depending on the actions we take in the near future.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LOST TO CLIMATE CHANGE:

The Bramble Cay Melomys

The Bramble Cay Melomys (or mosaic-tailed rat), a rodent with large eyes and dark brown fur, once lived only on Bramble Cay, a secluded speck of land surrounded by a coral reef and located in the north-east Torres Strait, between Papua New Guinea and Australia. The average Rising sea levels led to saltwater intrusions throughout the low-lying island, choking much of the leafy plants the melomys fed on. More frequent storm surges also impacted the population, sweeping the rodents out to sea.

Places like Torres Strait in the southern hemisphere experience more severe conditions during La Niña due to increases in cyclonic activity, wave energy and sea surface elevation. Seawater inundation events in January and February 2006, January 2009 and in 2012 were documented on as many as seven inhabited islands across the Torres Strait. This is against the backdrop of global mean sea level rise due to man-made global warming of around 20 cm since 1901.

The diminishing habitat combined with oceanic inundation ultimately led to the demise of the Bramble Cay Melomys, a fate that has been compared to a shipwreck. By 1998, the tiny vegetated cay of 5 hectares the species called home had been reduced to 2.5 ha by the erosion of wind, waves and tides. By 2014, the vegetated area that the melomys relied on for shelter and food had declined to 0.065 hectares (650 square metres) due to saltwater inundation.

In 1978, scientists documented several hundred individual melomyses on Bramble Cay. Twenty years later, a formal census captured 42 individuals and estimated a population of 93. In 2002 and 2004, censuses found only 10 and 12 individuals. In 2016, the Bramble Cay melomys became the first documented terrestrial mammal to go extinct because of man-made climate change.

More species that are endemic to low-lying reef islands are also at high risk of climate-change-driven extinction as they are not able to migrate to more habitable areas when their island homes are severely impacted by rising sea levels, changing weather and oceanographic regimes, and a greater frequency and intensity of cyclones.

The story of the Bramble Cay Melomys illustrates how ecosystems can experience the impacts of climate change well before extinction events start to occur.

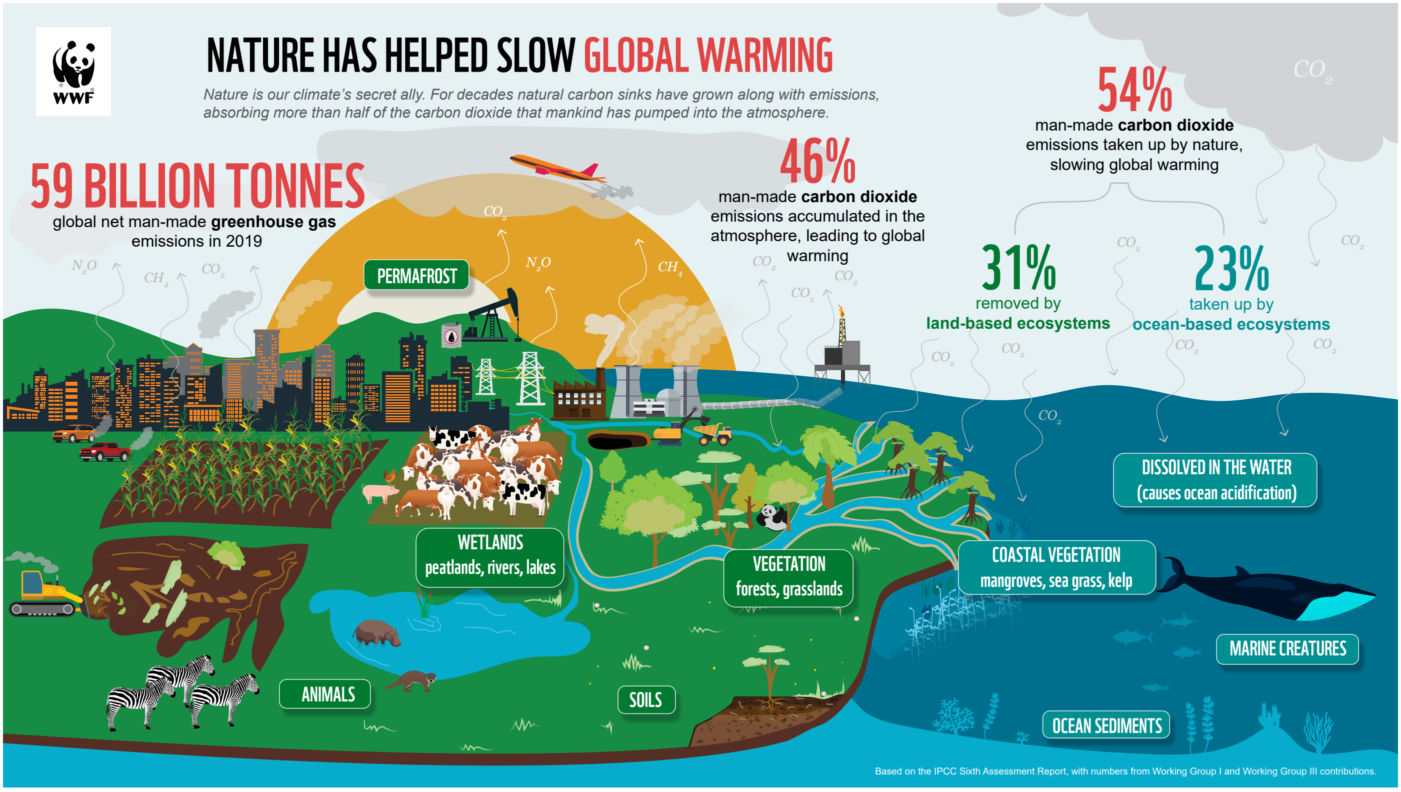
This case study is based on the IPCC Sixth Assessment Report and underlying studies.

NATURE: A SECRET ALLY IN THE FIGHT AGAINST CLIMATE CHANGE

Nature has historically been one of our most powerful allies. Behind the scenes, land and marine ***ecosystems play an important role in regulating climate****. Oceans, forests, permafrost, peatlands, coastal wetlands, savannahs and grasslands all act as 'carbon sinks', absorbing and storing carbon dioxide from the atmosphere and slowing global warming. Together all these ecosystems currently absorb over half of all annual human-made carbon emissions.*

What's more is that even though we are emitting increasing amounts of CO_2 in the atmosphere, those natural global sinks have so far remarkably kept up with the pace of emissions. They have grown and continued to **absorb the same proportion** of those emissions over the last six decades.

Between 1850 and 2019, the land and ocean sinks took up a total of 1,430 billion tonnes of CO_2, 59% of total emissions. In the last 10 years, annual CO_2 emissions reached the highest levels in human history. Of these, 46% accumulated in the atmosphere. The rest was taken care of by nature, with **ocean and land ecosystems respectively removing 23% and 31% of emissions**.



Without fail, nature has given humanity more than a **50% discount on climate change** and slowed down global warming. CO_2 concentrations in the atmosphere would be much higher were it not for the emissions removed by natural carbon sinks in vegetation, soils and oceans, with far worse climate impacts.

On land, vegetation captures CO_2 from the atmosphere through plant photosynthesis, and carbon then accumulates both in above and below-ground biomass and soils. **Stocks of carbon in terrestrial ecosystems** are about 3,500 billion tonnes of carbon (equivalent to over 12,800 billion tonnes CO_2) in vegetation, permafrost, and soils, over four times the carbon currently in the atmosphere.

Tropical forests and the Arctic **permafrost** contain the highest total carbon stocks in above-ground vegetation and in soil in the world. Permafrost is the soil that remains frozen throughout the year. The carbon in the permafrost has built up over thousands of years, as dead plants have been buried and accumulated within layers of frozen soil, where the cold prevents the organic material from decomposing.

As the world's largest tropical rainforest, the **Amazon** alone contains a stock of 45 to 60 billion tonnes of carbon (165 to 220 billion tonnes of CO_2). Altogether, it is estimated that tropical rainforests and Arctic permafrost prevent the emission of 1,400 to 1,800 billion tonnes of carbon (5,100 to 6,600 billion tonnes of CO_2) to the atmosphere that would otherwise increase the magnitude of climate change.

The **ocean** plays a vital role in slowing down global warming. Not only has the ocean taken up and stored 23% of carbon emissions in the last 60 years, but is also acting to balance the Earth's excess heat from rising global temperatures.

Vegetated coastal ecosystems such as mangrove forests, seagrass meadows, and salt marshes, which are sometimes described as '**blue carbon** ecosystems', also act as strong engines of global carbon storage. These habitats may not cover large areas but what they accomplish is powerful. On a per area basis, carbon stocks in coastal ecosystems can be much higher than in terrestrial forests. These ecosystems store carbon through a number of pathways, with most of it ending in sediments. Due to the capacity associated with such sediments, carbon can be locked away for long periods of time if undisturbed.

Ecosystems don't just regulate climate by sequestering carbon. They also exert an influence on regional climates through biophysical processes that modulate the balances of energy, water, and physical momentum across the atmosphere. The reflectivity of Earth's surface, referred to as albedo, affects global warming as it determines the amount of solar radiation that the land absorbs. For example, ice sheets reflect heat energy from the sun because they are light, conversely, forests absorb because they are dark. The surface roughness of forest canopies contributes to upward mixing of warm air into the atmosphere – drawing away heat and redistributing essential moisture.

In addition to slowing global warming, **nature keeps people safer from the impacts** of climate change, protecting houses, crops, water supplies, and vital infrastructure. For example, healthy ecosystems such as coastal wetlands and coral reefs provide natural seawalls that lessen the threats associated with rising seas and intense storms: coastal flooding and shoreline disintegration. They cause waves to break before they hit the shore, lowering the force and height of the swell and reducing the risk of the sea breaching over people's houses. They also increase resilience to cyclones.

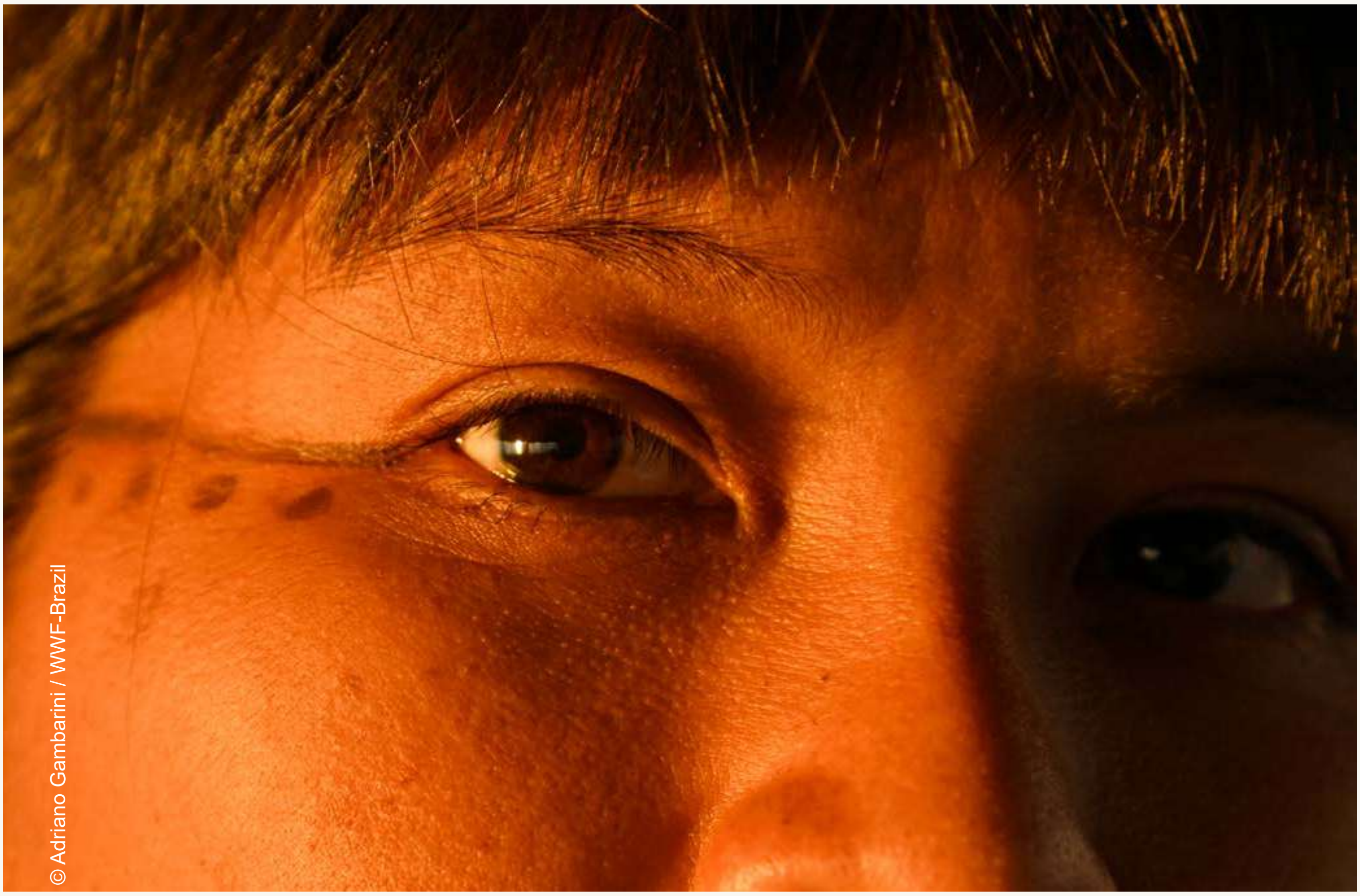
Healthy **wetlands** are like green infrastructures. They act as sponges, drawing water down through the ground and recharging groundwater supplies. They capture water during intense rainfall and store it for times of drought. Similarly, healthy forests recharge groundwater supplies by absorbing water through their roots, and in doing so, filter drinking water for millions of people worldwide.

Healthy, intact ecosystems also protect species, **strengthening nature's resilience** to climate change. Diverse systems can better withstand disturbances and recover from extreme events such as floods and drought more quickly.

Nature has our backs, but we have hardly noticed it. Instead we are **taking nature's role for granted** and have failed to protect what ultimately sustains all life on Earth. The continued destruction of natural ecosystems for agriculture, urban development and other human uses not only impacts biodiversity, but profoundly threatens nature' contribution to limiting climate change. For example, global deforestation has resulted in a loss of sink capacity of 3.3 billion tonnes of CO_2 between 2009 and 2018. Less than 30% of the world's forest are considered to be still intact and less than 40% of forest area has been estimated to contain forest older than 140 years.

What's left of nature is now bending under the weight of humanity and supports us at an increasing cost. For example, the constant CO_2 uptake by the ocean is gradually changing the seawater chemistry, which results in an increase in **ocean acidification**.

There are also **limits to how much natural carbon sinks can take**. As we release ever greater amounts of CO_2 in the atmosphere, it is projected that land and ocean ecosystems will continue to sequester carbon but take up a smaller proportion of emissions.



CASE STUDY

THE AMAZON RAINFOREST:
shifting state from sink to source

Comprising 6.9 million km², the Amazon forest spans nine nations and territories. *It stores approximately 17% of the vegetation carbon on the planet. The intact Amazon was one of the most powerful carbon pools on earth, with an uptake of around 0.5 billion tonnes per year (equivalent to around 1.8 billion tonnes of carbon dioxide).*

Since the early 2000s there is evidence of increased dieback in more than three-quarters of the Amazon forest, consistent with a loss of resilience. Exploring growth rates in trees has revealed that rates of growth (measured via net above-ground biomass) have declined by one-third during the past decade, compared to the 1990s.

At least 13% of the original Amazon forest is now lost and a further 17% is in a degraded state, with climatic pressure and fire at record highs. Under the combined pressures of climate change, extreme droughts, loss and degradation, concentrated in forests and the cerrado, in the south and east, parts of the biome have become a net carbon source in recent years, with emissions of more than 1 billion tonnes of carbon dioxide, annually.

Early warning indicators, based on observational data and modelling, reveal potential destabilisation of the Amazon forest. There is an important geographical element to the tipping point risk, in terms of where the areas with greatest loss are located. Whilst the forest is known to recycle a huge amount of the Amazon basin's rainfall, the work done by the trees to power the 'aerial rivers' is not evenly spread across the biome. Forests in the southern and eastern areas of the basin contribute most to the stability of other forest areas, whilst forests in the south-western Amazon have the opposite role – they are particularly dependent on transpired water 'subsidies' from the south and east. For the stability of the forest as a whole, the concentration of loss in the biome's southern 'deforestation arc' (where loss is up to 31%) is the worst possible geographical scenario.

More than 76% of the forest has already had its resilience from fire and drought reduced since the early 2000s. If the entire biome were changed to a degraded state, around 75 billion tonnes of carbon (equivalent to 275 billion tonnes of carbon dioxide) would be released to the atmosphere. Even this, rather than a total loss, has the potential to cause global warming of an additional 0.1°C to 0.2°C.

There is uncertainty around the tipping point, in terms of when, and how, the risk will progress, and the estimates of the tipping element thresholds.

This case study has been compiled from 'Risking The Amazon' a review of tipping points in the Amazon by the WWF UK

NATURE UNDER THREAT FROM CLIMATE CHANGE

*Around the world, global warming of **1.1°C is already causing dangerous and widespread disruption in nature**, wreaking havoc in marine, terrestrial, and freshwater ecosystems. Nowhere on earth is escaping dire climate hazards such as heatwaves, droughts, floods, and rising sea levels. From high mountain habitats to tropical coral reefs, the Arctic's frozen lands and the deep ocean, we are seeing the fingerprints of climate change across all natural systems.*

Heatwaves, storms and floods severely impact **freshwater ecosystems**. With little rainfall or adequate water flows, rivers' shallow areas are drying out, causing fish die-offs. In addition, between 1970 and 2010, water temperature has increased by up to 1°C and 0.45°C in rivers and lakes per decade. Warming waters lower dissolved oxygen concentrations, suffocate freshwater life, displace native fish, and facilitate the arrival of invasive species that are adapted to warm conditions.

In the **ocean**, warming, acidification and deoxygenation are disrupting entire food webs and hurting sea life in many ways. For example, ocean acidification makes it harder for oysters, mussels, and other organisms to build and maintain their shells. Acidification impacts calcium carbonate, which is a constituent of the skeletons and shells of a variety of marine organisms, and these can even begin to dissolve if the acidity gets too high.

On land, the changes in climate can create warmer, drier conditions, leading to longer and more intense **droughts and fire seasons**. In British Columbia, areas burned by wildlife have increased 7 to 11 times the natural levels in the extreme fire year of 2017. Meanwhile, trees are having a hard time surviving without water in prolonged drought. Up to 20% of trees have already been lost to drought in three regions in Africa and North America between 1945 and 2007.

In a desperate effort to follow the shifts in climate zones, many plant and animal species are moving away from the equator towards the poles. On land they also move towards higher, cooler elevations and for some marine species, down to deeper, cooler waters. Half of assessed plant and animal **species have already shifted their range** and are no longer found in the places where they used to be. Habitat fragmentation and barriers – such as mountains or settlements – can limit species movement. Ultimately, a warming world will become inhospitable for many species as the amount of suitable habitat for wildlife to survive is shrinking.

On the other hand, some **invasive species** thrive on climate change, claiming new territory and bringing new risks with them. For example, certain forest insect pests, such as the mountain pine beetle, have expanded northward into previously climatically unsuitable parts of boreal and temperate forests. Bark beetles also take advantage of milder weather conditions and produce more generations per year. As a result, some insects that were formerly considered harmless have become a significant cause of tree death as climates have warmed, with trees that are already weakened by drought and water stress more likely to be killed by beetle infestations, for example.

Climate change also facilitates the emergence and spread of new **diseases** that are now affecting wildlife and people in new regions. In the Arctic, warmer winters create favourable conditions for pathogens, vectors and some host animals, which in turn increases the population of disease organisms. Higher numbers of ticks, mosquitoes, deer flies, horseflies, and other insects that transmit a variety of pathogens are being seen in areas where they would not have been able to survive before.

Another deadly type of disease, caused by the **chytrid fungus**, is responsible for the catastrophic decline of over 500 amphibian species and the extinction of 90 species, mostly in tropical regions of the Americas and Australia. The chytrid fungus is being transported with high-elevation Andean frog species as they travel upward to avoid rising temperatures. In those new territories, the chytrid fungus is likely to spread with continued devastating impacts on more amphibian species.

Some species simply do not have the option to move, leading to **extinction**. In Costa Rica, the golden toad was the first species recorded to go extinct due to man-made climate change in 1990 after a series of extreme droughts. The intensification of drought also contributes to the disappearance of small or ephemeral ponds that often harbour rare and endemic species. The lemuroid ringtail possum in Queensland, Australia vanished after heatwaves in 2005. By 2009, only two individuals were found in the wild.

Long before species go extinct, **ecosystems begin to lose their integrity**, resilience, and overall ability to function when the local populations of specific animals are becoming rare. For example, when sea otters were hunted to near extinction in the 18th and 19th centuries, sea urchins lost their main predator and proliferated, which led to to the disappearance of kelp forests in the Pacific Ocean, demonstrating how the removal of one keystone species influences the health and integrity of an entire ecosystem.

As the world heats up, ecosystems are increasingly **exposed to climates that are more than they can tolerate**. With extreme weather events happening more often, there is just not enough time to recover and adapt. Some ecosystems will simply vanish with more global warming.

Marine heatwaves have doubled in frequency, become more intense, lasted for longer, and extended over larger areas in the last century. They cause coral bleaching and are responsible for mass mortalities of a wide variety of marine species, the stranding of marine mammals, fish population collapses, long-lasting ecosystem damage, and the loss of coastal livelihoods. Climate models project that by the end of the century marine heatwaves will be 20 times more frequent than they were between 1850 and 1900 even if warming is limited to 2°C.

Warm-water **tropical coral** reefs support some of the most biodiverse ecosystems on the planet, providing shelter, food and spawning grounds to thousands of marine species. In the last 30 years, half of the planet's tropical coral reefs have already disappeared because of pollution, overfishing and unsustainable coastal development. Now they are affected by ocean acidification and extreme temperatures driven by climate change, which are leading to large-scale and back-to-back coral bleaching events. At 1.5°C warming, coral reefs are projected to decline by 70 to 90% by 2050. At 2°C, more than 99% of these corals will be lost, with devastating impacts on marine ecosystems and the communities that rely on them for food, storm surge protection and more.

Marine heatwaves also have profound impacts on cold-adapted **kelp forests** that cannot tolerate higher temperatures and become vulnerable to the predation of herbivores such as sea urchins. One of the largest and longest marine heatwaves, nicknamed 'the Blob', occurred in the Northeast Pacific Ocean, extending from California north towards the Bering Sea, from 2013 to 2015, when temperatures in the upper ocean reached up to 6.2°C above average. Warming from the heatwave continued in 2016 off the West Coast of the United States and in Canada in 2018. Amongst the devastating impacts of the heatwave, there was a toxic algal bloom off the West Coast of the United States and a significant decline in California kelp forests that contributed to the collapse of the abalone fishery.

Some **species are hit in multiple ways** by climate change. Seabirds are unable to find fish to feed their chicks as warmer waters trigger food chains to be out of sync. During the 2014–2015 Pacific heatwave, around one million common murres died of starvation along a 1,500 km coastal stretch in the Pacific in the United States. At the same time, rising sea levels impact seabirds that can no longer build nests and raise young on low-lying islands that face inundation and bigger storms.

On land, **heatwaves and drought** are also severely damaging ecosystems and cause mass animal deaths, pushing some species to the brink of extinction. During a heatwave in 2014, 45,500 flying foxes died in just one day in eastern Australia. In South Africa, 14 species of birds and fruit bats suffered mass die-offs in 2020 due to extreme heat, including African penguin eggs and chicks.

Long before climate change had started to take its toll on biodiversity, humans have been responsible for **the massive loss of nature**. Human activities have destroyed or degraded all types of carbon-rich and biodiverse ecosystems of the Earth, including tropical forests, mangroves, grasslands, and seagrass meadows. Over a third of natural habitats have been converted to agricultural lands to feed a growing population while much of the oceans has been overfished and freshwater resources are extracted for irrigation. Today, less than 15% of the world's land, 21% of the freshwater and 8% of the ocean are protected.

Other threats to nature such as habitat destruction, overexploitation of natural resources, pollution all exacerbate the impacts of climate change to push the world's natural systems to the edge, with catastrophic consequences for biodiversity.

Across the globe, there are many examples of the escalating impacts of the **interactions between habitat destruction and rising temperatures**. For example, nutrient runoff from agricultural activities on land into the ocean combine with climate change to reduce oxygen in coastal waters to dangerously low levels and create 'dead zones', where marine species cannot survive.

While there is no cliff edge to the climate crisis, each tonne of carbon emitted into the atmosphere will increase the chance of more hot extremes and rainfall changes and more devastation to biodiversity. **Every increment of warming will wipe out more species** from the face of the Earth. In land ecosystems, up to 14% of all assessed species face a very high risk of extinction at global warming of 1.5°C, and this increases to up to 18% at 2°C.

Warming is also profoundly changing how ecosystems function, putting into motion ecological processes that, themselves, in time cause more warming: this process is called a '**positive climate feedback**' – but this is more of a vicious cycle. Increases in wildfires, tree mortality because of drought and insect outbreaks, soil moisture reductions, peatlands drying, and tundra permafrost thawing, all these processes are starting to transform natural systems that have historically been secure carbon sinks into new carbon sources that release more CO_2 as dead plant material decomposes or is burned. With more warming and ecosystem degradation, nature's vital role as a climate ally is increasingly compromised.

Deforestation contributes to climate change by releasing carbon emissions, altering rainfall cycles, and creating warmer, drier climates that in turn increase droughts and fires. Deforestation, agricultural expansion, intentional burning, and climate change have already turned the Amazon rainforest into a net carbon source between 2010 and 2019. Deforestation accounts for 45% of total land-use emissions including agriculture.

Other ecosystems are also switching from carbon sinks to carbon sources. For example, **peatlands** have historically stored about 25% of the world's soil organic carbon and 10% of freshwater resources, despite only occupying 3% of the global land area. Now, extreme weather events, fire, and human disturbances such as draining for agriculture or mining has led to rapid peatland carbon losses across the world.

In Indonesia and Malaysia for example, the draining and burning of **peat** swamp forests for oil palm plantations have converted this ecosystem from a carbon sink to a carbon source between 1990 to 2015. In the Baltic, Scandinavia, and continental Europe, rising annual temperatures have lowered peatlands' water tables, dried out and killed peat moss, and increased the intensity and frequency of fires, resulting in a rapid carbon loss.

Much of the shallow **permafrost**, the glue that holds together so much of the north's landscape, is projected to thaw under 2 to 4°C of global warming. When 'nature's freezer' thaws, it releases CO_2, methane, and other greenhouse gases that amplify global warming and lead to ground instability, threatening human settlements and infrastructure. An average temperature rise of 2°C could reduce the total permafrost area by up to 20% by 2100. Projections of the resulting carbon losses vary widely, and it is estimated that between 15 billion tonnes and nearly 70 billion tonnes CO_2 could be released. Those losses are possibly underestimated as most projections only consider the upper permafrost layers. By comparison, human activities have released about 40 billion tonnes of CO_2 into the atmosphere in 2019.

Some ecological processes can reach a so-called **'tipping point'**, which is a threshold beyond which an abrupt and large-scale change in a system occurs. Once a tipping point is crossed, the effects can be irreversible over time scales of decades, centuries or longer. Crossing a tipping point can cause rapid ecosystem collapse and species extinction. This is one of the biggest risks from an 'overshoot' scenario in which the global temperature rise exceeds the 1.5°C or 2°C threshold for at least a decade or more[4].

An example of a system on the brink of a tipping point is the collapse of Greenland and Antarctic **ice sheets**, the largest reservoirs or frozen freshwater and therefore the largest potential contributors to sea level rise. For example the amount of water held in Greenland's ice sheet would

4 Overshoot refers to pathways that first exceed a specified global warming level, typically for one or more decades, and then cool down below that level again before the end of the century. The most ambitious pathways assessed by the IPCC are categorised together as '1.5°C with no or limited overshoot'.

raise global sea level by seven metres over centuries if it completely melted.

Other tipping points include the abrupt thawing of the permafrost and the dieback of tropical and boreal forests. It is projected that with continued deforestation combined with a warming climate, the Amazon rainforest will cross a tipping point into a dryer savannah ecosystem state this century.

Climate change and biodiversity loss are not just environmental issues. They impact all aspects of people's lives. People are part of and dependent on natural systems. As ecosystem degradation and climate change increasingly compromise nature, it is the future of humanity that is also compromised. When ecosystems are no longer functioning properly, people lose access to the essential ecosystem services nature provides: drinking water, food security, air quality, disease protection, pollination of crops for food, and the ability to adapt to a changing climate.

Extreme weather events have made **feeding the global population more difficult.** Droughts, heatwaves, floods, storms, and climate-related pest outbreaks have multiple impacts on food production, from crop loss to storage and transport disruption, and diminished food quality.

For example, while **plagues of desert locusts** have occurred for millennia, outbreaks are expected to occur more often because of climate change. In 2019, desert locust swarms infested Eastern Africa and damaged 200,000 hectares of crop and pastureland, placing two million people in an acutely food insecure situation. The infestation was facilitated by two tropical cyclones that created desert lakes in a usually dry region of Saudi Arabia, while moist soils, warm temperatures, and vegetation provided the right conditions for desert locust to breed and migrate to Yemen and Somalia.

Climate change has already **decreased agricultural productivity growth** by 21% since the 1960s. Between 1983 and 2009, approximately three-quarters of the global harvested areas experienced yield losses because of drought. High temperatures and extreme rainfall degrade the quality of soils, ultimately impacting food production.

The global ocean and inland waters together provide more than 3.3 billion people at least 20% of the protein they eat and provide livelihoods for 60 million people. Due to climate change, the amount of **fish that can be sustainably harvested** has decreased on average by over 4% between 1930 and 2010, with some regions experiencing up to 35% losses The loss of coral reefs will impact 6 million directly coral-dependent fishing jobs as well as the 1.3 billion people in the tropics who depend on fisheries for food and livelihoods.

Bees pollinate many types of wild plants as well as agricultural crops. The loss of the important ecosystem services they provide threatens food security and overall biodiversity. It is estimated that the complete removal of **pollinators** could reduce global fruit supply by 23%, vegetables by 16%, and nuts and seeds by 22%. The changing climate impacts pollinators by shifting growing and blooming seasons and weakening the plant populations that pollinators depend on. Bee populations are also declining because of the use of harmful pesticides such as neonicotinoids, particularly in the United States and Europe.

Global warming is altering the distribution of many land, marine, and freshwater species, impacting millions of people that have relied on resources from the land and the sea for food security and livelihoods. As marine species are moving poleward in response to a warming ocean, some local communities are losing access to traditional seafood sources. This global geographic shift will impact the equitable distribution of food, as higher latitude countries which are on average richer and have higher greenhouse gas emissions, are more likely to benefit from fish that migrate poleward. Tropical, poorer and lower-emitting greenhouse gas countries will suffer from the loss of critical resources.

In the **Arctic**, climate-driven changes are profoundly affecting the ways of life, food security, and cultures of Indigenous Peoples who rely on the ice, land and sea. The decline in snow impacts ice-dependent species, alters migratory patterns of important food species such as caribou, and reduces local communities' access to traditional hunting grounds.

Climate change is also impacting **water security** in many regions of the world. Between 1.5 and 2.5 billion people are currently exposed to water scarcity in the world. These numbers will climb up to 3 billion at 2°C of warming by 2050.

Longer dry spells and droughts are reducing **water availability**, especially in the arid areas of India, China, the United States and Africa, while heavy rains and flooding make water unsafe for drinking. In coastal regions and small islands, higher sea levels and intense storms increase the salinisation of groundwater resources, which ultimately reduces water supply for people. Additionally, extreme weather events can destroy critical water infrastructure, especially in developing world regions, creating sanitation problems and increasing disease risk.

Projected **impacts on agriculture** due to changes in water availability are also severe. For example, yields of rain-fed crops such as maize are projected to decline by one fifth to one third by the end of the century. Irrigation is also projected to be affected by a reduction in water in some parts of the world that are already water-stressed or as a result of groundwater depletion in places such as India, North China and the northwestern United States. At 2°C of global warming, regions that are highly dependent on snowmelt could experience a decline of up to 20% in water availability for agriculture beyond 2050.

People, nature, and climate are interconnected. Increasing temperatures and extreme weather brought on by climate change causes biodiversity changes and loss of ecosystem services, which subsequently leads to more climate change, which causes more biodiversity loss, and ultimately threatens all life on Earth, including humans. **The nature and climate crises are two sides of the same coin that must be tackled together**.

CASE STUDY

THE MEKONG DELTA:

Between a Rock and a Hard Place

Vietnam's Mekong Delta, one of Southeast Asia's most productive agricultural regions, could be nearly submerged by the end of the century if no urgent action is taken. The Delta is home to approximately 17 million people and supports industry, services, agriculture and fisheries that represent one-quarter of Vietnam's GDP. The delta produces half of Vietnam's staple crops and nearly 90% of its rice exports. Vietnam is one of the world's top rice exporting countries.

Rivers carry sediment and when rivers meet the slower-moving water of the sea, much of that sediment load is deposited. This process forms and maintains deltas. Like other river deltas, the Mekong Delta can only continue to exist if it receives a constant sediment supply from its upstream basin, and if water flows can spread that sediment across the low-lying delta surface to build land at a rate that is equal to or greater than local sea level rise. Exacerbated by climate change, waves and coastal storms now tend to tear down deltas and if the sediment delivered by rivers is not replenished, deltas begin to shrink and sink, a trend that is observed around the world.

Historically, the Mekong carried the 10th largest sediment load among world rivers. But the delta has already lost 70% of that sediment load because of unsustainable human activities, such as the capture of sediment within reservoirs behind dams and intensive sand mining in the lower river. With sediment loss, the Mekong Delta is now experiencing accelerated erosion and the intrusion of saltwater deeper into the land, threatening millions of livelihoods.

Countries in the basin have built numerous hydropower dams that trap sediment and reduce downstream flows. Often presented as a climate solution that produces low-carbon electricity, more hydropower dams are now proposed for the Mekong delta. The construction of just a handful of these large dams would capture enough sediment to reduce the delta's supply to just 10% of the natural rate.

Already vulnerable to sea-level rise that is changing the landscape faster than normal, the Mekong Delta is now the centrepiece of a climate mitigation strategy that will deprive this fragile ecosystem from the sediment it needs to counteract sea-level rise. However there is strong evidence that the region's countries can meet targets for low-carbon electricity without building the dams that would cut off the delta's vital sediment supply. Wind and solar solutions are some of the affordable options that can support climate mitigation while safeguarding the integrity of ecosystems such as the Mekong Delta that supports wildlife and people.

Supporting hydropower development over the continued health of the Mekong Delta is an example of how climate change maladaptation can harm natural ecosystems and compromise their resilience to climate change.

This case study has been provided by the WWF Freshwater Practice

WORKING WITH NATURE AS A CLIMATE SOLUTION

Nature has historically shielded humanity from the worst impacts of climate change. But ***we are now at a turning point*** *as the Earth's web of terrestrial and marine ecosystems are succumbing to human pressures.*

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Effectively and equitably conserving between 30 and 50% of Earth's land, freshwater and ocean ecosystem will help maintain resilience of biodiversity and ecosystem services at a global scale, and safeguard peoples' livelihoods, and the food and water they depend on. **We need all hands on deck** as there is just a small window of time remaining to take decisive action to prevent irreversible harm to the natural systems that have protected us for so long. This means exploring all solutions which can provide mitigation and adaptation.

CO_2 emissions from fossil fuels and industry contribute 64% of global man-made greenhouse gas emissions. If we want to safeguard nature's helping hand we need to undertake rapid, deep, and sustained **emission cuts across all sectors of the global economy**. This includes energy and transportation to buildings and food to give people and ecosystems a fighting chance of adapting to climate change. Fossil fuel use must be slashed, and by 2050 nearly all electricity supply should be from zero-, or low-carbon sources such as renewables.

We need to **scale up** renewable energy, such as wind and solar power, use less energy through improved efficiencies, move towards lower-carbon transport such as walking and cycling, electrified vehicles and public transport, **moderate demand** for aviation, change consumption patterns, and move towards more healthy sustainable diets.

Yet the world is not on track to achieve these goals. In fact, between 2010 and 2019, average annual global greenhouse gas emissions were at their highest levels in human history. Currently, human activities are emitting around 40 billion tonnes of CO_2 into the atmosphere in a single year. At this rate, our remaining **carbon budget** – the total net amount of CO_2 emissions that humanity can still release – will be depleted within 10 years for a 1.5°C target, and thirty years for 2°C of warming[5].

To halt global warming, global CO_2 emissions need to reach **'net zero' –** which is where man-made emissions are balanced by removals over a specified period. Scenarios which limit global warming to 1.5°C with no or limited overshoot are characterised by rapid, deep and sustained emissions cuts with residual emissions balanced by carbon sinks by the early 2050s.

5 According to the 2022 NDC Synthesis Report (UNFCCC) the combined climate pledges of 193 Parties under the Paris Agreement could put the world on track for around 2.5°C of warming by the end of the century.

Even if global warming is stabilised, some **risks will continue to increase** due to long response times in the Earth system. The Greenland and Antarctic ice sheets will continue to melt, sea level will keep rising, ocean acidification and deoxygenation will increase, and those changes will be irreversible over our lifetime and many more generations. It will take centuries to millennia for some of the natural systems to react and adjust.

While deep, rapid and sustained emission cuts are necessary, these will not be sufficient to achieve net-zero CO_2 emissions. Humanity will also need to take active steps to **remove carbon dioxide from the atmosphere** to balance remaining emissions that may be too difficult or too costly to abate, for example from aviation, agriculture and some industrial processes.

People are exploring a variety of technological solutions to remove carbon dioxide from the atmosphere. Yet the most ancient, efficient, and **proven greenhouse gas removal solution comes from nature** itself. After all, land and ocean ecosystems have already absorbed about half of the CO_2 emissions humanity generates.

However, the IPCC highlights that we have destroyed many carbon-rich ecosystems, weakening their capacity to regulate the climate and releasing even more emissions into the atmosphere. Deforestation and land degradation continue to be a source of global greenhouse gas emissions, with net emissions from the **agriculture, forestry and other land-use sectors**, (known as AFOLU) accounting for 22% of total greenhouse gas emissions in 2019.

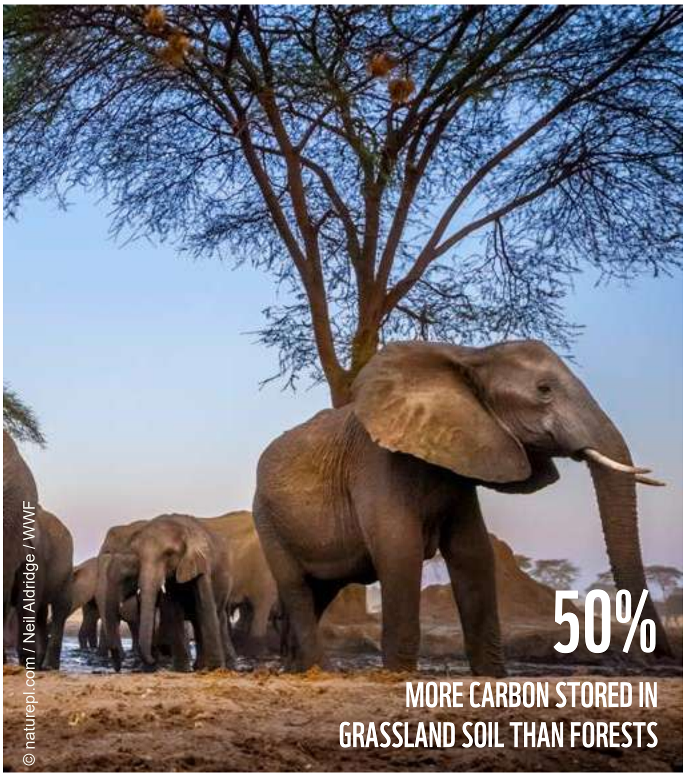
The climate crisis cannot be tackled without improving our stewardship of nature and the way land is used. The **mitigation potential of the AFOLU** sector could reduce global greenhouse gas emissions by 8-14 billion tonnes of CO_2 equivalent per year between 2020 and 2050 at costs less than USD 100 per tonne. These mitigation estimates are in addition to the more than 50% of man-made emissions that nature already provides. The protection, improved management, and restoration of forests, peatlands, coastal wetlands, savannahs and grasslands provide the largest potential to cut and/or sequester emissions by an average of 7.3 billion tonnes of CO_2 equivalent per year, with measures that 'protect' having the single highest total potential and mitigation per area. Conserving carbon-dense ecosystems, including peatlands, coastal wetlands and forests is particularly important because much of the carbon and ecosystem services lost from those ecosystems takes decades to centuries to recover.

Intact **natural forest ecosystems** are major stores of carbon. Living tropical trees are estimated to hold 200 to 300 billion tonnes of carbon or about one-third of the levels in the atmosphere. Tropical forests are also home to two-thirds of our world's biodiversity, although they only cover about 13% of the land on Earth. About 1.3 billion people also depend upon forest resources for their livelihoods.

Yet between 1990 and 2020, over 420 million hectares of forest were lost to **deforestation**, threatening biodiversity, carbon stocks, ecosystem services, forest communities, and overall resilience to climate change. More than 90% of forest loss took place in tropical areas.

Grasslands cover 40.5% of global land, with Sub-Saharan Africa and Asia having the most extensive total area. It has been estimated that grassland soil carbon stocks are nearly 50% more than is stored in forests worldwide. Grasslands also harbour a wealth of biodiversity and are home to iconic species like elephants, rhinos, and tigers.

Yet, global **grasslands have been destroyed at an alarming rate**. Between 1700 and 1992, 6.7 million square kilometres of savannah, grassland and steppe habitats were converted to croplands, with more than 80% of these habitats converted to farms and settlements by



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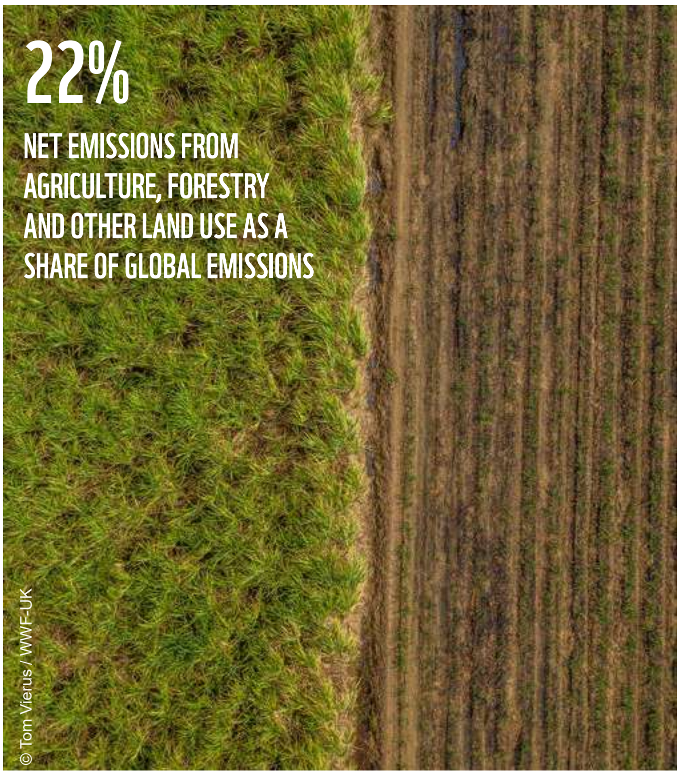

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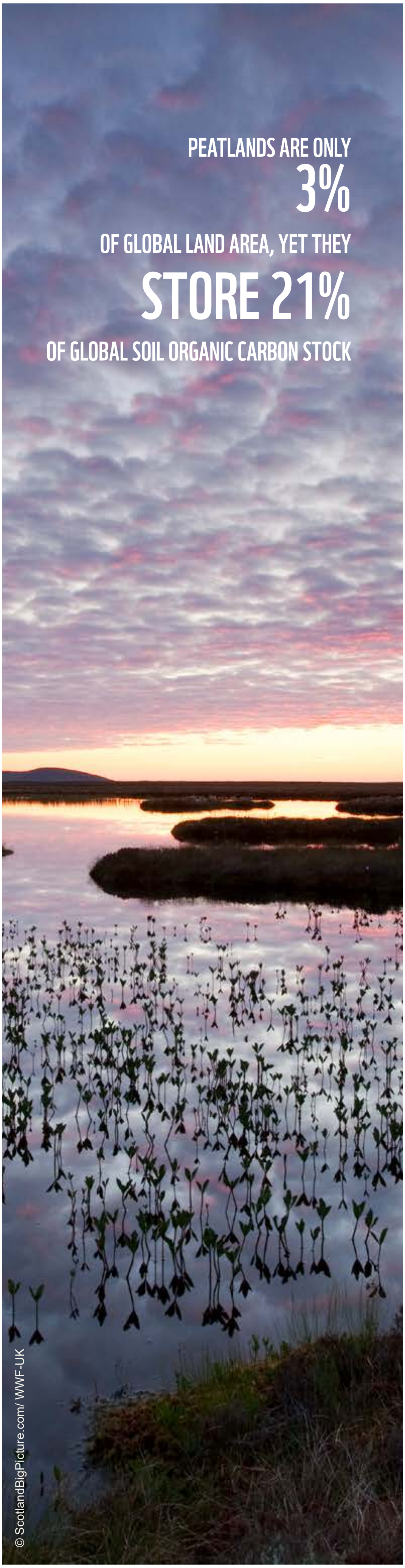

2000. In North America, grasslands are disappearing at an equivalent rate to deforestation in the Amazon. Half of the Brazilian Cerrado tropical savannah has been converted to agricultural land and pastures, with consequences on the climate. It is estimated that around 36% of soil carbon stocks are lost after 20 years following the conversion of grasslands to pasture or cropland.

Conserving and recovering nature is not just a tool for carbon dioxide removal. When we protect and restore ecosystems, we do more than boost their carbon storage potential. We also enhance biodiversity and bring back the full suite of ecosystem services nature provides. These nature-based solutions, or ecosystem-based approaches carry benefits for nature, people, and climate[6]. Healthy ecosystems strengthen people's ability to face climate change, building resilience against a future of rising sea-levels, desertification, extreme flooding and wildfires, as well as supporting livelihoods and food security.

For example, **peatlands** only account for about 3% of the global land area. Yet they may store about 600 billion tonnes of carbon or 21% of the global total soil organic carbon stock. Peatland carbon stocks accumulate slowly and persist over millennia. When we restore degraded and damaged peatlands through rewetting and revegetation for example, we can increase carbon accumulation and avoid ongoing CO_2 emissions, but there are even more benefits such as conserving critically endangered species, ensuring water supply for people and nature, improving public health, and protecting infrastructure against flooding.

Often located in estuaries and deltas that are densely populated, **coastal wetlands and seagrass meadows** are extremely vulnerable to human pressures. Destroyed for aquaculture, agriculture, salt ponds, urban and infrastructure development, these ecosystems are being lost at rates between 0.7% and 7% per year with significant CO_2 emissions. Like for peatlands, the restoration of mangroves, salt marshes, and seagrass meadows provides an effective way to remove carbon dioxide from the atmosphere. At the same time, these restored ecosystems can protect coasts from the impacts of storm surges and sea level rises by significantly attenuating wave energy and raising the seafloor. Additionally, they support the livelihoods and well-being of native and local communities, providing fish and shellfish.

For all their benefits to nature and people, **nature-based solutions are not a silver bullet to the climate crisis**. Nature does play a critical role, but people can't just fix ecosystems, sit back, and let nature do all the work. Nature is no substitute for drastically cutting emissions.

Harnessing the power of nature to combat climate change is also not just about wilderness habitats. **Cities and urban areas**, where over two-thirds of the global population are projected to live by 2050, are hotspots of climate risk and opportunity. Urban centres and cities are warmer than the surrounding rural areas due to what is known as the urban heat island effect. This urban heat island effect results from several factors, including reduced ventilation and heat trapping due to the close proximity of tall buildings, heat generated directly from human activities, the heat-absorbing properties of concrete and other urban building materials, and the limited amount of vegetation. Additionally, coastal and low-lying cities face increasing risks from sea-level rise, tropical cyclones, storm surge, intense rainfall and coastal flooding.

6 Nature-based solutions leverage nature and the power of healthy ecosystems to protect people, optimise infrastructure and safeguard a stable and biodiverse future. Ecosystem based Adaptation (EbA) is a related term recognised internationally as the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change.

Cities and urban areas hold untapped potential for people and nature to work together and mitigate climate change. Global urban trees store approximately 7.4 billion tonnes of carbon and sequester approximately an additional 217 million tonnes of carbon annually (nearly 800 million tonnes of carbon dioxide). **Urban nature-based solutions** include creating green space in cities with trees and connected networks of parks promoting green roofs, and urban agriculture. These approaches benefit people, nature, and the climate: they improve carbon uptake and storage; provide shading and cooling effects that reduce heat island effects; help water drainage; reduce air pollution, contribute to food security and access to freshwater; increase biodiversity; and rebuild urban residents' connection to nature for mental and physical health.

Food systems are also critical levers for both reducing pressure on nature and using nature to benefit long-term food security. Between 23 and 42% of global greenhouse gas emissions are associated with food systems – from the production, processing, transport, consumption, and disposal. Improved agricultural practices, including agroecological farming, livestock and nutrient management, improved rice cultivation and soil carbon management, have the potential to reduce greenhouse gas emissions by an average of 4.1 billion tonnes of CO_2 equivalent per year between 2020 and 2050 at costs under USD 100 per tonne. Various agricultural measures can also help with climate adaptation. For example, agroforestry, where trees or shrubs are grown around or among crops or pastureland, planting cover crops, selecting longer rooted cultivars and other practices that support vegetation cover and build soil organic matter also improves the water-holding capacity of soils and buffers against drought.

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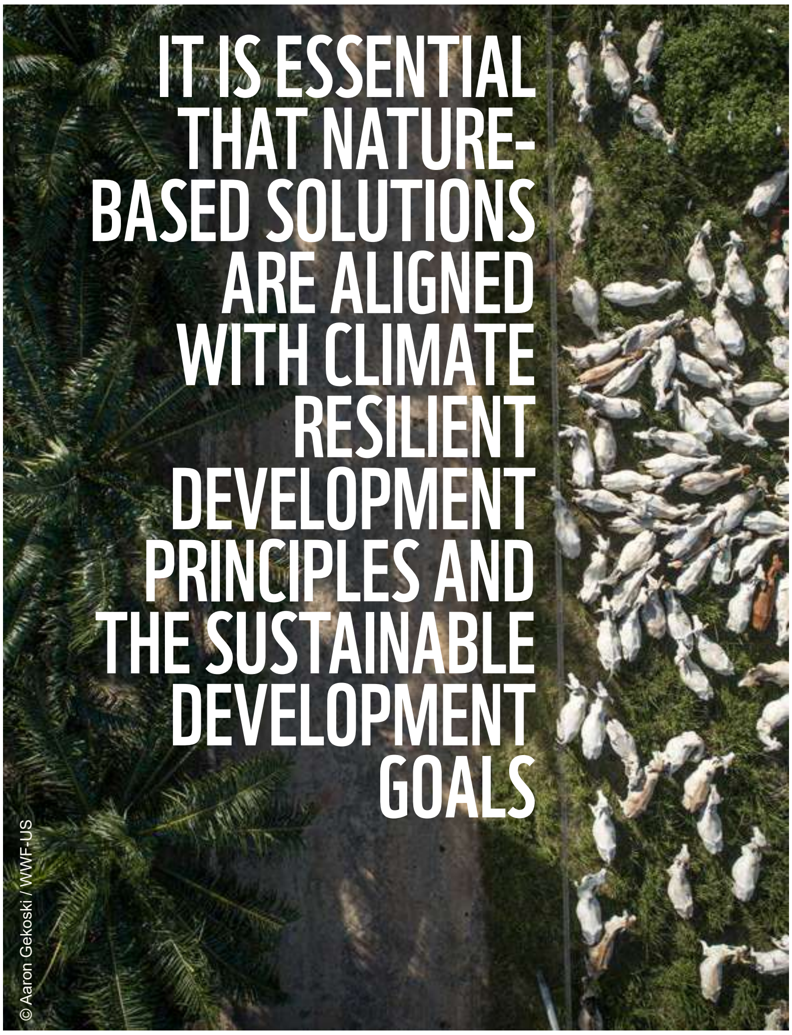
Changes in consumption and disposal practices in the food system, including reducing food loss and waste and shifting to sustainable healthy diets can mitigate an average of 6.5 billion tonnes of CO_2 equivalent per year when accounting for the entire value chain including land-use effects like reduced deforestation. These measures can enhance supply chain efficiencies, lower costs and reduce agricultural land needs, as well as improve human health and wellbeing. Demand-side actions are also critical for enabling the protection and restoration of ecosystems, as well as reducing methane and nitrous oxide emissions from agricultural production.

Transformed **agricultural systems that work with nature can also enhance biodiversity.** Nature patches or corridors within an agricultural region help species move between habitats; hedgerows along fields provide habitat for many flowers, birds and insects. In turn, farm biodiversity benefits pollination, pest control, nutrient cycling, water regulation, soil fertility, which ultimately enhances long-term food security. For example, it was found that biodiverse agroforestry systems supported up to 45% more biodiversity and 65% more ecosystem services compared to conventional production of timber and crops and profits from livestock in the Atlantic Forest in Brazil.

© Jason Houston / WWF-US

While nature is a powerful ally in the fight against climate change, we must also be aware that **inappropriate climate actions can hurt nature**. For example, planting trees in the wrong places can damage biodiversity and even increase greenhouse gas emissions.

Just because trees can grow somewhere, it does not mean that they should. Natural systems like **grasslands and savannahs are important in their own right**, storing carbon in soils, supporting rich biodiversity, and providing people with important ecosystem services. Large-scale planting of trees in these habitats can threaten wildlife species that are adapted to these environments, while impacting areas that serve as forage for livestock. Grassland ecosystems are also naturally dry, and planting trees there uses a lot more water, reducing stream flow and groundwater. Additionally, fire intensity can increase. Restoring those natural ecosystems instead of afforesting them can increase carbon storage, support biodiversity, and strengthen nature's overall resilience to climate change.



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According to the IPCC scenarios, large-scale **carbon dioxide removal is needed to reach net-zero** emissions to stop further global warming. However, some technologies, if they were to be implemented at scale, can introduce a range of new risks which are not well understood. For example, bioenergy with carbon capture and storage (BECCS) is used in climate models to draw down carbon from the atmosphere by growing plants that are used for energy and the CO_2 subsequently stored in geological formations.Yet this technology remains unproven at scale, and requires large areas of land and natural resources to grow bioenergy crops which can impact biodiversity, water and food security, and livelihoods, especially in regions with insecure land tenure.

Poorly planned climate adaptation can turn into **maladaptation** if actions result in unintended negative consequences for people and nature, for example when coastal ecosystems are destroyed to build dykes or seawalls to provide hard defences against flooding. Such actions can weaken natural processes and reduce ecosystems' resilience to climate change and their ability to provide natural buffers for adaptation, and may even cause more emissions of greenhouse gases.

To realise nature's full potential while avoiding harm to biodiversity and people, it is essential that nature-based solutions are aligned with **climate resilient development** principles and sustainable development goals. Climate resilient development combines strategies to adapt to climate change with actions to reduce greenhouse gas emissions to support sustainable development for everyone.

Critical barriers need to be overcome in order to effectively adopt nature-based solutions and align with climate resilient development. These barriers include institutional capacity, multi-level governance, financial systems and lifestyle changes. It is crucial that all nature-based solutions are people-centred, led by communities and draw from traditional and local knowledge.

Indigenous Peoples and local communities have worked with nature for millennia. While they are a fraction of the global population, Indigenous Peoples are custodians of most protected areas in many parts of the world and have long histories of adaptation to climate hazards.

Transformative change is urgently needed if we are to combat both biodiversity loss and the climate crisis. Solutions will need to be deployed in the right places with inclusive governance that incorporates scientific, local and Indigenous knowledge.

CASE STUDY

THE FOREST KEEPERS:

Living in Harmony with Nature

There are over 370 million Indigenous People in the world, in 70 countries on five continents. Indigenous Peoples view both themselves and nature as part of an extended ecological family that shares ancestry and origins. They acknowledge that nature's contributions to people are vital for human existence and good quality of life.

At least a quarter of the global land area is traditionally owned, managed, used or occupied by Indigenous Peoples. In addition, a diverse array of local communities, including farmers, fishers, herders, hunters, ranchers and forest users, manage significant areas under various property and access regimes.

In the United States, the Menominee people, also known as 'the Forest Keepers', have practised sustainable forestry – the centrepiece of the tribe's economy – on their reservation in Wisconsin for the last 160 years. Their land is a non-fragmented remnant of the prehistoric Lake States forest, where density has been dramatically reduced. The Menominee people balance forest growth and removals, prioritising high quality trees over large volumes, according to the principle of continuous forest inventories. Today, 87% of the land in the collectively maintained reservation is placed under sustained yield forestry, which includes multiple forest types which are more diverse than adjacent forests. Forest volume standing is now greater than when timber harvesting began.

The approach of the Menominee people in balancing the environment, community, and the economy for current and future generations is an example of effective and sustainable land protection. Yet nature managed by Indigenous Peoples and local communities is under increasing pressure from global changes in climate, biodiversity and ecosystem functions.

Many Indigenous Peoples and local communities have been proactively confronting such challenges in partnership with each other and with a variety of other stakeholders, through co-management systems and local and regional monitoring networks and by revitalising and adapting local management systems. As a result, in many regions, the lands of Indigenous Peoples are now becoming islands of biological and cultural diversity surrounded by areas in which nature has further deteriorated.

This case study is based on information contained in WGIII Box 7.8 of the IPCC Sixth Assessment Report

CONCLUSION

Today we face the double, interlinked emergencies of climate change and the loss of biodiversity, threatening the well-being of current and future generations. As ***our future is critically dependent on biodiversity and a stable climate****, it is essential that we better understand how nature's decline and climate change are connected.*

Climate change is bringing an increasing number of worsening threats to people and nature, including heat waves, droughts, heavy rainfall and rising sea levels. Depending on how we choose to safeguard and restore land, sea and freshwater, these threats can be reduced or made worse. Ultimately, how we manage our relationship with nature will determine the future of the planet and people.

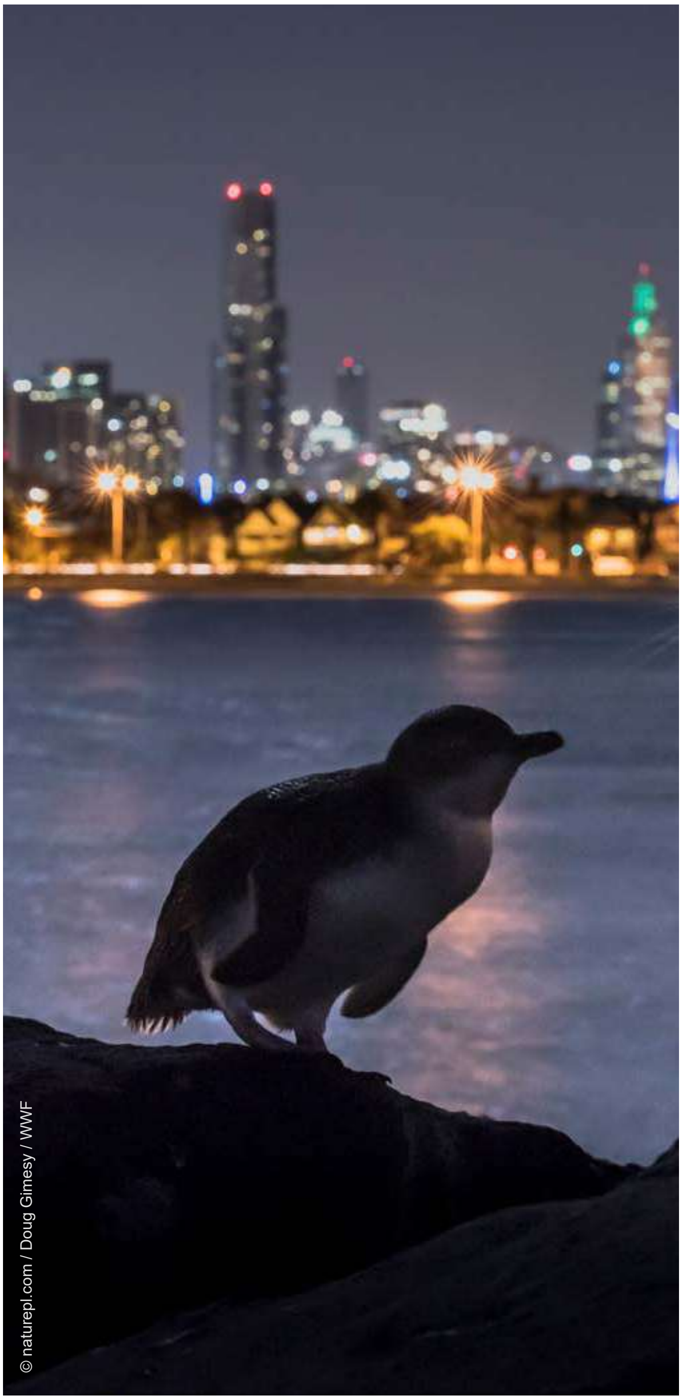
Healthy and diverse ecosystems absorb and store more carbon, provide life-critical services such as food and clean water, and protect humanity from climate risks such as storms and floods. Nature's intrinsic benefits are also worth protecting for their own sake.

If we want to effectively harness the power of nature, we urgently need to conserve, enhance and restore the diverse ecosystems of our planet – including forests, peatlands, grasslands, mangroves, saltmarshes and seagrass meadows. To maintain resilience of biodiversity and ecosystem services at a global scale, between 30 and 50% of Earth's surface must be effectively and equitably conserved.

Nature has been hard at work behind the scenes to limit and reverse the effects of humans pumping more and more greenhouse gases into the atmosphere for generations, but we cannot expect nature to carry the burden of the climate crisis alone. Safeguarding and restoring ecosystems will support climate resilience and increase mitigation, but that alone is not enough. Nature itself is vulnerable to climate change and that places additional stress to the integrity and functioning of ecosystems. The hotter the planet gets, the harder it is for natural systems to bounce back. This means that while the measures we take to restore and protect habitats and species are vital, they will not prevent irreversible losses without faster emission cuts for example through decarbonising the global energy system.

Nature-based solutions and ecosystem-based approaches will only work effectively in combination reducing emissions by phasing out our reliance on fossil fuels. We need to be nature's ally and do our part by undertaking deep and immediate emissions reductions across all sectors. If we maintain global warming at 1.5°C, there are still prospects for natural solutions making an impact in the fight against climate change. But higher levels of warming will severely undermine nature's ability to help.

The bottom line is that unless there are immediate, rapid, and large-scale reductions in carbon dioxide, methane, and other greenhouse gases, limiting warming to 1.5°C will be beyond reach. Every choice we make to avoid even small increases in warming results in fewer losses and damages to nature and people. If we take action now, nature can continue to be our ally for climate resilient development, economic growth, and a low-carbon future where people and nature can thrive together.



WWF RECOMMENDATIONS

WWF has uncovered the story of nature and climate change within the thousands of pages of the IPCC Sixth Assessment Report. ***Nature is our climate's secret ally – it has slowed global warming and offers protection from climate change impacts****. But nature has limits for both mitigation and adaptation, and unless we safeguard and restore nature we run the risk of losing it as an ally, and with that the goal of limiting warming to 1.5°C.*

Governments accepted the work of the IPCC in its Sixth Assessment as a comprehensive, objective and balanced summary of the latest science. Country Parties to the Paris Agreement also welcomed the IPCC findings at UNFCCC COP26 in Glasgow, and acknowledged the value of using the best available science for effective climate action and policy decisions. Governments must therefore ensure that climate strategies appropriately deliver the right outcomes on nature, climate and people across the whole economy. As part of this, they must strengthen national tools for effective climate action and support –- such as institutional capacity, multi-level governance, financial systems and lifestyle changes. To achieve this, WWF calls on countries to put in place the following recommendations around safeguarding and restoring nature and decarbonising energy systems when developing and delivering their climate and biodiversity national responses:

SAFEGUARDING AND RESTORING NATURE

Governments must protect, manage, restore and create healthy natural ecosystems: According to the IPCC, maintaining the resilience of biodiversity and ecosystem services at a global scale depends on effective and equitable conservation of approximately 30 to 50% of Earth's land, freshwater and ocean areas, including currently near-natural ecosystems. Strategies to conserve important ecosystems include halting conversion of nature; designating biodiversity hotspots as protected areas; and transforming the food system.

Safeguarding and restoring nature is non-negotiable if we are to adapt to and to slow climate change – and with the right approach, governments can also support climate resilient development. A nature-based solutions approach helps focus efforts where vulnerable people and ecosystems are co-located. Nature-based solutions should aim, where possible, to integrate mitigation and adaptation actions (such as reefs protecting coastal areas from storm surges or trees cooling urban areas) as well as disaster risk reduction, to better advance climate resilient development. High quality nature-based solutions interventions should guarantee biodiversity net gain and ecosystem integrity.

A climate resilient development approach should also build partnerships with Indigenous Peoples and local communities on building appropriate strategies for conserving nature according to local circumstances, and in a nationally determined manner. This includes supporting human rights and equity, such as improving land-tenure rights that encourage collective ownership and Indigenous land rights.

Effective conservation can help **maintain nature as a climate ally** when Governments:

- **Strengthen nature in domestic climate plans and strategies.** Targets to conserve at least 30% of land, freshwater and oceans, restore degraded ecosystems, and a milestone to halve the footprint of consumption and production by 2030.
- **Scale-up on-the-ground conservation efforts.** Governments should integrate conservation objectives across legislation, policy making and implementation. In doing so, they should establish nationally determined approaches which support climate resilience development, participation and equity.
- **Integrate responses to address the climate and nature crises.** We call upon all Parties to multilateral conventions, including the United Nations Framework Convention on Climate Change, the Convention on Biological Diversity and the 2030 Agenda for Sustainable Development, to recognise consistent principles on how the climate and nature crises must be tackled together:
    - **A nature positive mission:** to ensure there is more nature in the world in 2030 than there was in 2020, and which is delivered through a rights-based and whole of society approach**.**
    - **Conserved habitats:** Targets to conserve 30% of land, freshwater and oceans and restore degraded ecosystems globally by 2030;
    - **Footprint:** A milestone to halve the footprint of consumption and production by 2030 and targets covering all sectors driving nature loss;
    - **Implementation:** A strong and effective implementation mechanism to ratchet up action over time;
    - **Finance:** A significant increase in resources, together with measures to align financial flows to be nature positive and to repurpose all harmful subsidies by 2030;
    - **Nature-based solutions:** The inclusion of nature-based solutions, alongside ecosystem-based approaches, to deliver benefits for people, climate and nature.

DECARBONISING ENERGY SYSTEMS

Governments must show **leadership and political will to cut global greenhouse gas emissions** consistent with limiting global warming to 1.5°C. This means rapid, deep and sustained global cuts on the order of 43% below 2019 levels by 2030, and net-zero CO_2 emissions by 2050. In the near term, this should include prioritising a just transformation in the energy sector that also takes full account of the impact on biodiversity

Clear signals to drive a fossil-fuel free energy system include setting ambitious climate targets according to national circumstances. This should include an ambitious timeline to phase out coal, oil and gas, and national legislation supported by policies and finance in all sectors.

In the near term, the road to a just energy transformation can support **climate resilient development** through just transition planning while also putting in place economic signals supporting the uptake of renewables and energy efficiency across all sectors. This includes leaders putting in place the economic and social policies that prioritise environmental and social goals, including access and security, and upholding high employment and social rights.

The energy transition should support a **nature positive approach** through:

- Phase-out of coal and no exploration for new coal, oil and gas resources.
- Phasing out existing oil and gas production and infrastructure in line with the 1.5°C threshold. Taking into consideration the different realities in producing countries, high- and upper-middle income countries should take the lead and end oil and gas production by 2040, while low- and lower- middle income countries should end production by 2050.
- Shifting subsidies and investments away from fossil fuels and into nature-positive and zero -emission investments, ensuring the financing of just transitioning, and energy access according to the special needs of developing countries.
- No new fossil-fuel-based infrastructures, be it for production, refining, or transport, and the decommissioning of existing infrastructure should include the restoration of the original ecosystem functions of the area.
- Prioritising the decommissioning of existing fossil fuel activities taking place in areas of high biodiversity importance and sensitivity (e.g. protected areas, key biodiversity areas, Arctic marine and intact forest landscapes).
- Accelerating the transition of fossil fuel based systems towards sustainable energy systems that facilitate renewable energy and associated novel business models.

Working to sustain the natural world for the benefit of people and wildlife.

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For contact details and further information, please visit our international website at **www.panda.org/climateenergy**