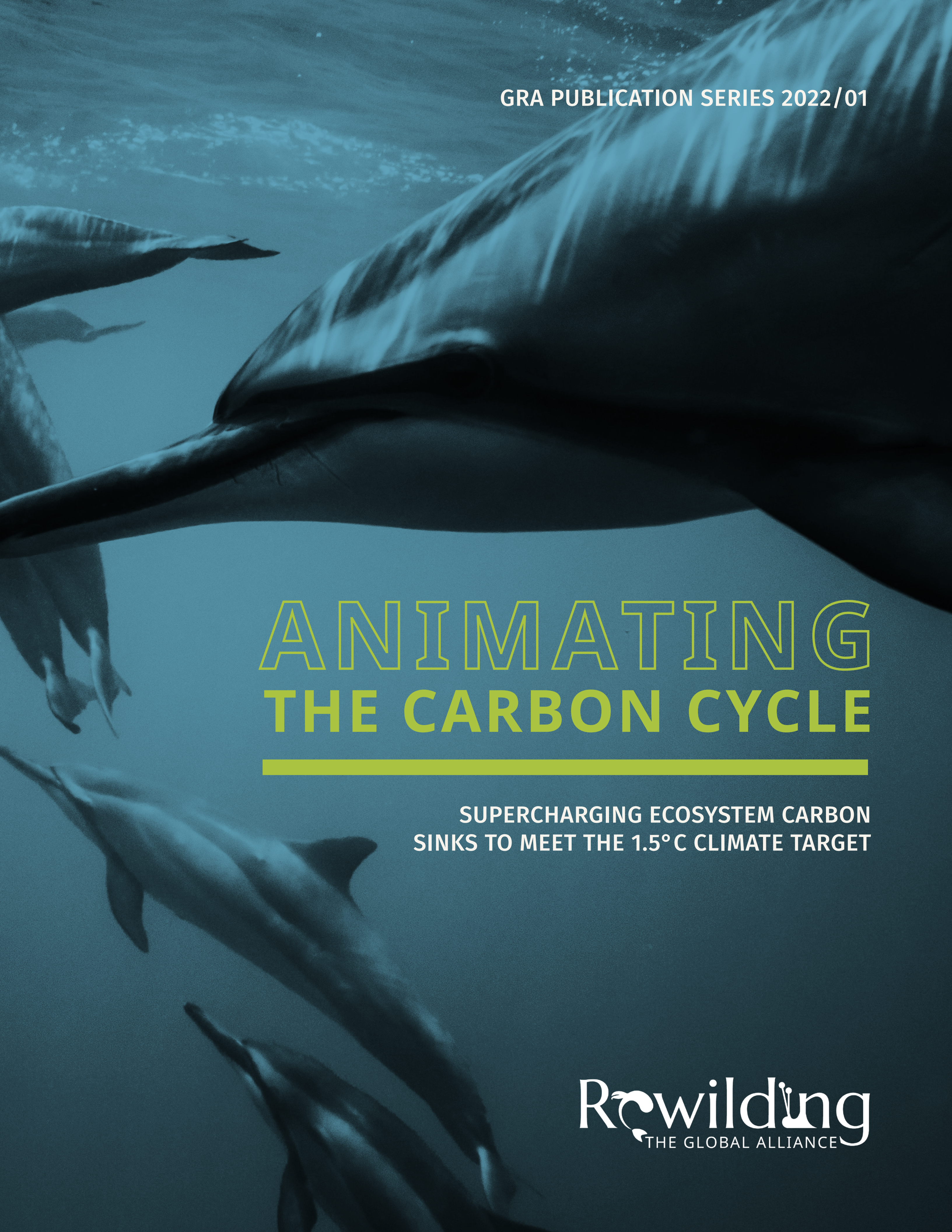

GRA PUBLICATION SERIES 2022/01

ANIMATING THE CARBON CYCLE

SUPERCHARGING ECOSYSTEM CARBON SINKS TO MEET THE 1.5°C CLIMATE TARGET

Rewilding
THE GLOBAL ALLIANCE

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The GRA is a network of rewilding practitioners and messengers based on the Global Charter for Rewilding the Earth (a product of planning for the 11th World Wilderness Congress, 2020).

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Cover + back cover photo: Jeremy Bishop

Introduction

Towards a new paradigm

Against the backdrop of biodiversity decline and rising global temperatures, there has never been a greater awareness of our need for nature and the wide range of benefits it provides. Practical rewilding initiatives have already demonstrated that by enhancing so-called nature-based solutions, recovering nature can - and should - play a game-changing role in fixing our climate, increasing biodiversity, and making the world a more liveable place for future generations.

Yet despite the clear link between the climate and biodiversity emergencies, the current paradigm for identifying and developing nature-based solutions remains one of reconciling trade-offs. It is still a commonly held assumption that dedicating landscape space to conserve and enhance biodiversity will conflict with the allocation of landscape space to capture and store carbon. In places where conservation initiatives could lead to the realisation of both benefits, it is widely assumed that carbon capture and storage and biodiversity conservation are functionally unrelated.

This assumption overlooks the critical role that biodiversity - particularly animal species - plays in controlling carbon uptake and storage in ecosystems. Indeed, scientific research is now showing that restoring wildlife populations to significant, near historic levels has the potential to "supercharge climate mitigation." This science is called: "Animating the Carbon Cycle (ACC)."

Game-changing impact

Animals influence the carbon cycle in myriad ways. Herbivores, for example, affect the exchange of carbon between ecosystems and the atmosphere through their grazing, by redistributing seeds and nutrients over vast areas of land and sea, and by trampling and compacting soils and sediments. They can have a positive impact on climate change by increasing the amount of carbon drawn down and stored in plants, preventing outbreaks of wildfire, protecting against permafrost thawing, and increasing soil and sediment-based carbon retention.

"Restoring wildlife populations to significant, near historic levels has the potential to supercharge climate mitigation."

Photo details & credit:
African elephant

Carnivores also play a critical role. Recent studies have shown that the loss of important predators - from wolves in boreal forests to sharks in seagrass meadows - can lead to growing populations of terrestrial and marine herbivores, whose widespread grazing reduces the ability of ecosystems to absorb carbon. In aquatic ecosystems, whales and fish act as nutrient translocators, consuming prey in deep water and excreting nutrients at the surface, stimulating the production of phytoplankton which pulls carbon dioxide (CO2) into the water column.

"Restoring, rewilding, and conserving the functional role of vertebrate and invertebrate species can be a climate game changer"

OSWALD SCHMITZ

Based on complex interactions and impacts such as these, the potential for restoring marine, freshwater and terrestrial wildlife populations to help stabilise the climate is huge."Restoring, rewilding, and conserving the functional role of vertebrate and invertebrate species can be a climate game changer by magnifying carbon uptake by 1.5 to 12.5 times (in some cases more) across the world's ecosystems," says Professor Oswald Schmitz of the Yale School for the Environment, a key originator of the ACC concept.

It's clear that rewilding can be a great ally in the fight against climate change. This means it's time to change the narrative around wildlife conservation. Instead of framing wild animals as "victims of humanity's doomed climate voyage", they should be seen as real and significant climate heroes. Since less than 3 percent of the Earth's terrestrial surface can be considered functionally intact, and 97 percent of the ocean is open to fishing of some kind, the needs and opportunities for "rewilding the climate" are as huge as they are necessary.

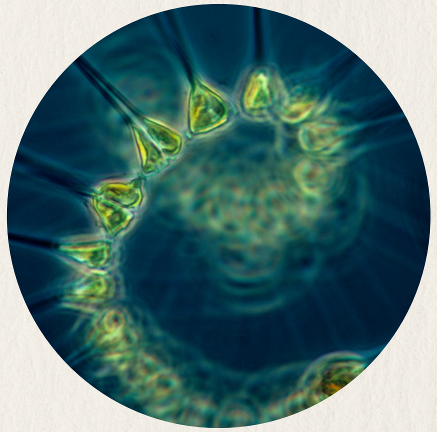


Photo details & credit:
Phytoplankton, Photo by NOAA

Cases in point

There are already numerous examples of how different animal species positively impact ecosystem carbon storage. In Africa, the restoration of wildebeest on the plains of the Serengeti has almost completely prevented wildfire outbreaks, while rejuvenated grasslands now capture carbon that may equal the annual anthropogenic CO2 emissions of Kenya and Tanzania.
By protecting wolf populations across the North American boreal region, an amount of carbon equivalent to 10 percent of the annual CO2 emissions of the US could potentially be drawn down and locked up in vegetation every year. And by restoring the forest elephant population in the Congo Basin to historic levels, an amount of carbon equivalent to the annual CO2 emissions of France would be stored.

The marine environment boasts similar examples. If whale populations were restored to their estimated pre-historic population levels, the annual CO2 emissions of Russia - or more than the entire emissions of Africa - could be captured. Despite the severe degradation of global fish stocks, they still capture an amount of carbon equivalent to twice the CO2 emissions of the European Union. Just imagine the climate change mitigation potential of such stocks if they were fully restored.

A more detailed overview of these examples and others can be found in the case study section, starting on page 7.

Photo details & credit: Kruger National Park, South Africa, Photo by ReWild Africa

A unique opportunity

Rewilding, which now offers us a unique opportunity to upgrade nature for the first time in human history, is characterised by its inspirational narrative and emphasis on practical action. The animation of the carbon cycle though rewilding and restoration aligns with this characterisation perfectly. As a cost-efficient, immediate, and scalable nature-based solution, the enhancement of wildlife populations can play a key role in addressing both our climate and ecological emergencies.

"To ensure the full range of benefits that such animation offers are realised, we urgently need to scale up restoration and rewilding on a global scale."

VANCE MARTIN

To demonstrate the potential of this approach further, a high-level group of 60 scientists, economists, and civil society organisations have launched an initiative titled "Animate the Carbon Cycle: Supercharging ecosystem carbon sinks to meet the 1.5oC target". By 2024, this will confirm the massive, yet highly undervalued impact that intact and functional nature has on stabilising the climate, and the huge and timely opportunity that restoration and rewilding presents.

Leading this initiative is a consortium of organisations facilitated by the Global Rewilding Alliance. It includes One Earth, the Yale School of the Environment, Re:wild, GRID-Arendal, Rewilding Argentina, the Wilderness Specialist Group (IUCN), and the WILD Foundation. This new coalition advocates a very simple solution: **preserving intact nature and immediately restoring and rewilding functional ecosystems at landscape and seascape scale.**

"By supercharging ecosystem carbon sinks, the animation of the carbon cycle presents us with a unique opportunity to address the climate emergency and meet the 1.5˚C target," says Vance Martin, President of the WILD Foundation. "To ensure the full range of benefits that such animation offers are realised, we urgently need to scale up restoration and rewilding on a global scale."

Keeping 1.5 alive:

Why we need wildlife

The 2016 Paris Agreement brought together almost all of the world's nations - for the first time ever - in a single agreement to reduce the anthropogenic greenhouse gas emissions causing global warming. These nations agreed to pursue efforts to limit global temperature rises to 1.5°C. Such efforts are currently focused on reducing net fossil fuel CO2 emissions to zero by completely shifting towards renewable energy generation by 2050, together with ending deforestation and changing land use to prevent the release of carbon already stored within ecosystems.

Even if they are completely successful, these efforts will not be enough to achieve the 1.5°C target. This is because there is already too much CO2 in the atmosphere. There is therefore a need to remove CO2 from the atmosphere and store it as sequestered carbon in terrestrial, freshwater and marine sinks. Estimates indicate that 500 GtCO2 needs to be removed and stored between now and 2100 (or approximately 6.5 GtCO2 yr-1) to achieve the 1.5°C target. Based on what we already know about the influential role animals play in the carbon cycle, the restoration of wildlife populations - on land and in water - will be essential if we are to accomplish this objective.

"Estimates indicate that 500 GtCO2 needs to be removed and stored between now and 2100 to achieve the 1.5°C target."

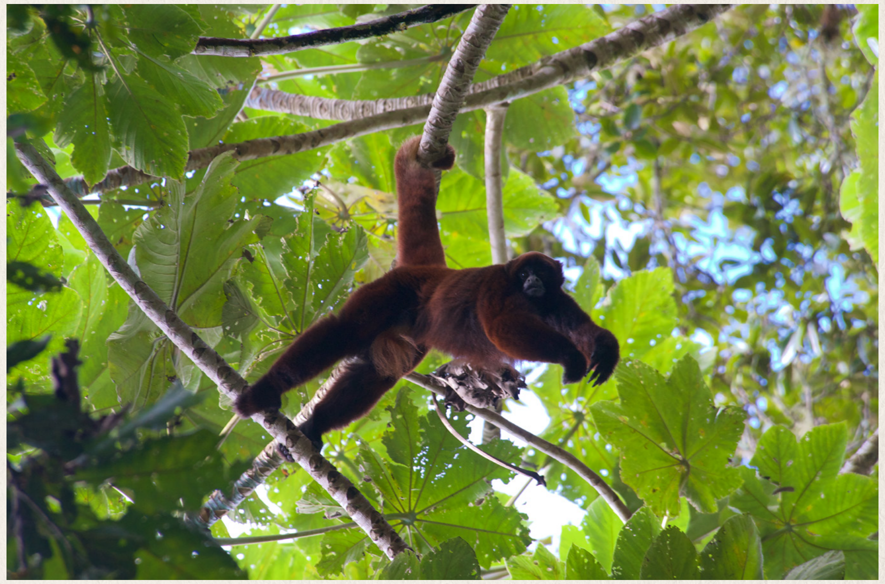


Photo details & credit: Yellow-tailed woolly monkey, Corosha, northern Peruvian Andes.
Photo by Russell Mittermeier, Re:wild

CASE STUDIES

Climate change is commonly viewed as causing collateral damage to biodiversity. Wildlife species, particularly animals, are widely perceived as unwitting victims - passengers trapped aboard a ship on an ill-fated voyage.

In reality, animals play a critical role determining the course of the climate ship. From elephants to grasshoppers, sharks to sea otters, species of all descriptions, habitats and climate zones impact global carbon exchange in different ways. Within a complex web of interactions, some have a greater impact than others, while the impact of the same species may vary from ecosystem to ecosystem.

The following case studies showcase the diversity and complexity of the relationship between animals and the global carbon cycle, both in terrestrial and marine environments. They also demonstrate just how important it is to protect and restore wildlife populations as we look to address climate change.

CASE STUDY:1

Beavers:
A dam good climate solution?

More research is required before the net effect of beavers on carbon storage is fully understood. Nevertheless, there is huge potential for beaver population restoration to mitigate climate change.

Photo details & credit:
American beaver, Photo by Niklas Hamann

When it comes to reshaping their surroundings, beavers have a lot in common with people. They fell trees and construct dams to block waterways, radically changing the world around them to better suit their requirements. The tenacious work ethic of these influential ecosystem engineers leads to the creation of healthy wetland and riverine habitat that benefits an array of plants and other animals.

Yet the impact of beavers isn't limited to the physical landscape. They also play a complex role in the carbon cycle and climate change.

A beaver family usually changes territories once every three to five years, but can also stay in the same area as long as twenty years. After beavers abandon their territory (or they die or are killed), the dam they have constructed gradually disintegrates and the pond behind it drains away. It may fill up again in the future if beavers return, with many beaver habitats in a constant flux between terrestrial and aquatic ecosystems. In this way, beavers affect carbon biogeochemistry on both short and relatively long timescales.

The elevated water table behind intact beaver dams prevents oxygen from getting to much of the wood and other organic matter buried in sediment there. This means it decomposes more slowly. In fact, wood buried in waterlogged beaver meadows can last around 600 years - longer than a typical log that falls in a forest. But when dams fail water levels drop, soils dry out, and the decomposition process begins to release CO_2 back into the atmosphere.

A 2012 study carried out in Rocky Mountain National Park in Colorado discovered that sediment upstream of active beaver dams contained about 12 percent carbon by weight (most of it locked in wood). By comparison, sediment in abandoned beaver meadows contained less than 4 percent. The research team calculated that while abandoned beaver meadows in the study area contained 736,000 tonnes of stored carbon, they could potentially have stored 2.7 million tonnes if their beaver dams had been reoccupied and the landscape rewetted. If this impact is extrapolated to cover the entire traditional range of the beaver in North America, it suggest that these industrious rodents - and their relatively sudden removal from the landscape (up to 400 million beavers may have lived in North America before they were almost completely wiped out by trappers in the 1700s and 1800s) - may have had a substantial effect on global climate.

400 million
Number of beavers that may have lived in North America before trappers almost wiped them out.

However, things aren't quite as simple as this. Beaver ponds also release varying levels of CO_2, methane and nitrous oxide (the latter two are far more potent greenhouse gases than CO_2). A 2018 study carried out by a Finnish research team found that beaver ponds range from carbon sinks to carbon sources, depending on a variety of factors. This spatial and temporal variation in greenhouse gas emissions means beaver ponds and meadows **could fix as much as 470,000 tonnes of carbon per year on a global scale, or alternatively release up to 820,000 tonnes.**

More research clearly needs to be done in this area. Yet while there is much we have yet to understand about the net effect of beavers on carbon storage, there is good reason to believe that the widespread restoration of beaver populations could have a beneficial impact on global climate.

CASE STUDY:2

Elephants:
The gardeners of the Congo

Photo details & credit: African forest elephant, Photo from Robin James Backhouse

As the so-called "gardeners of the Congo", critically endangered forest elephants play an outsized role in rainforest carbon sequestration.

Elephants are a significant driver of vegetation change and treefall in the landscapes where they live. As they move through the jungle, devouring plants and swatting aside saplings, Africa's elusive forest elephant may seem like an animal intent on chaotic destruction. In actual fact, this little-studied species plays a hugely beneficial role in mitigating climate change by driving significant levels of carbon sequestration.

Most of us learn about two species of elephant at school - the African and the Asian. Yet in 2021, the International Union for Conservation of Nature (IUCN) formally recognised two distinct species of African elephants: the bush (savanna) elephant and the forest elephant. The latter is less bulky than its more well-known relative, and tends to roam in smaller groups and at lower densities. They are typically only seen when visiting openings in the forest to drink.

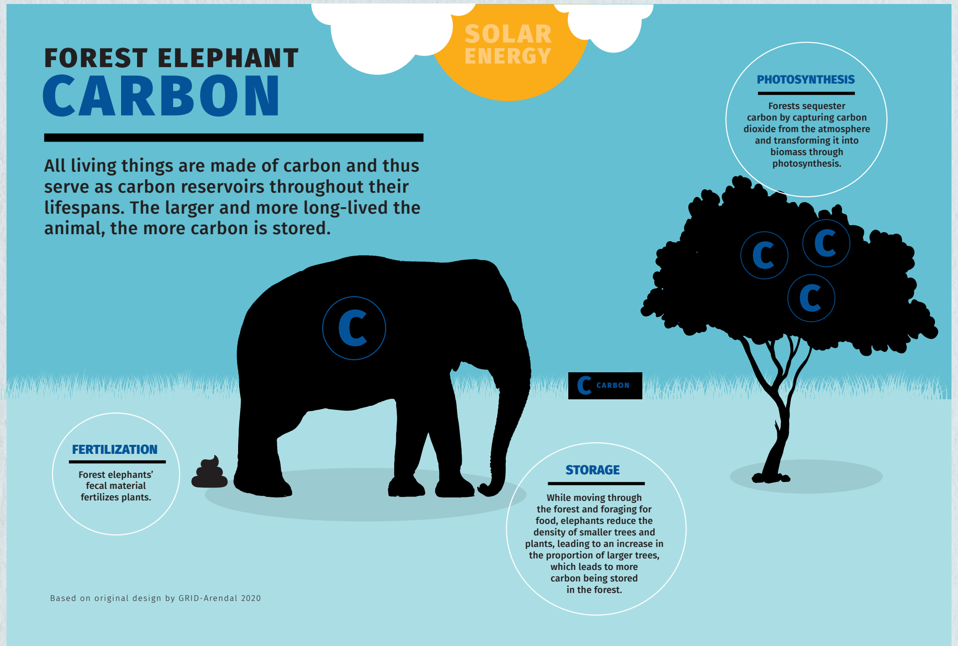
Forest elephants live in the humid, tropical forests of the Congo Basin and throughout West Africa. Feeding on lush leaves, seeds, fruit, and tree bark, they forage the landscape for food. Nicknamed "the gardeners of the Congo", they consume huge amounts of vegetation and plant material, stomping on small trees and bushes as they move from place to place. Acting as forest engineers, they effectively remove faster-growing softwood trees from the landscape, helping to promote the growth of slower-growing, taller, higher density hardwoods that are capable of storing more carbon (see infographic).

Scientists modelling this process have come up with some incredible numbers. It has been estimated that by tilting the biological balance in favour of certain types of trees, disturbance by forest elephants (at their typical density) could increase aboveground biomass by up to 54 tonnes per hectare, with each elephant helping to capture over 9,000 tonnes of CO_2 during an average lifetime. The carbon capture services of Africa's forest elephants have been valued at $150 billion per annum by Ralph Chami, a leading green economist and Assistant Director at the International Monetary Fund.

9K tonnes

Amount of carbon each elephant can capture in its lifetime.

Scientists have also calculated that the disappearance of forests elephants entirely could see Central African rainforests lose seven percent of their biomass. This equates to a loss of nearly three billion tonnes of carbon - **the equivalent of France's anthropogenic CO_2 emissions for 27 years**. Such a disappearance is not altogether improbable - while more than 1 million forest elephants are once estimated to have roamed the jungles of Africa, the impact of illegal poaching and deforestation means there may now be fewer than 100,000 left.



CASE STUDY:3

Fish:

The excretion effect boosts the oceanic carbon pump

Recent research has shown that excretion by fish accounts for much of the blue carbon than sinks to the seabed.

70%

Percentage of earth's surface is water and plays a critical role in absorbing CO2.

The oceans cover more than 70% of the Earth's surface and play a critical role in absorbing CO2 from the atmosphere. Estimates suggest that around a quarter of all anthropogenic CO2 emissions are taken up by the ocean, although recent research suggests the oceanic carbon sink could be even larger. The ability of the ocean and marine ecosystems to capture and store carbon has slowed the pace of global warming, although it has also led to ocean acidification, which can have a hugely negative impact on marine life.

CO2 from the atmosphere dissolves in the surface waters of the ocean. Much of it stays as dissolved gas, but some is turned into organic matter through photosynthesis by tiny marine plants (phytoplankton). Through an important process called the biological pump, this organic carbon is transferred from the surface to ocean depths when algal material or faecal pellets from fish and other organisms sink. The daily migration of fish to and from the depths also contributes organic carbon particles, along with excreted and respired material.

While fish are the dominant vertebrates in the ocean, the scale at which they help to sequester atmospheric CO2 remains poorly understood. A study carried out in 2021 estimated that carbon in fish faeces, respiration, and other excretions makes up about 16% of the total carbon that sinks below the ocean's upper layers. That equates to roughly 1.5 billion tonnes every year - **or an amount of carbon equivalent to twice the CO2 emissions of all 27 Member States of the European Union.**

More research needs to be carried out to understand exactly how climate change and seafood harvesting impacts the role of fish in oceanic carbon cycling. A recent study has shown that bottom-trawling releases as much carbon from the seabed as the entire aviation industry. This is another reason why marine protected areas (MPAs) - which currently cover a fraction of the ocean floor - need to be extended. More (properly enforced) MPAs could lead to enhanced carbon sequestration by increasing populations of fish and other marine species, as well as boosting fishery yields and food security.

1.5 billion

tonnes of carbon contained in fish faeces, respiration, and other excretions sinks below the ocean's upper layers every year.

Research has also revealed that 43.5 percent of the blue carbon extracted through commercial fishing between 1950 and the present day has come from areas of the ocean that would have been unprofitable to fish without subsidies. Limiting blue carbon extraction by fisheries, particularly in unprofitable areas, would not only reduce CO2 emissions from fuel use, but help to sequester more atmospheric carbon by enabling fish stocks to recover, thereby boosting the biological carbon pump.

Photo details & credit: School of duskyshoulder trevallies, Amed Beach, Indonesia. Photo by Milos Prelevic

CASE STUDY:4

Invertebrates:
Small animals with a big impact

Invertebrate wildlife species mediate the global carbon cycle through various trophic pathways. In grasslands, invertebrate predators - and their influence on foraging by invertebrate herbivores - could contribute significantly to such mediation.

Photo details & credit: Hunting spider, Photo from Oswald Schmitz, Yale School of Environment

One of the symptoms of global biodiversity decline is trophic downgrading - the disproportionate loss of species occupying the higher trophic levels of ecosystems. This can cause significant changes in plant biomass, composition, and diversity, as a loss of carnivores leads to changes in both herbivore density and foraging behaviour. In this way the loss of top predators can have a significant impact on ecosystem carbon dynamics - from sea otters in the ocean to wolves in the boreal forest.

This kind of cascading effect and its impact on carbon cycling isn't limited to vertebrate wildlife species. This was aptly demonstrated by a 2013 study carried out on Connecticut grasslands, involving two types of spider predators - one a "sit-and-wait" spider and the other an active hunter - as well as their grasshopper prey, and a number of grasses and herbs.

The results from the study showed that the presence of the two different spiders with their two different hunting modes has a very different impact on ecosystem carbon storage. When sit-and-wait spiders were present as the dominant predator, the grasshoppers were observed to modify their foraging in favour of a relatively carbon-rich herb called Solidago. This is a key source of dietary soluble carbohydrate for the insects, which they use to fuel sustained levels of heightened respiration brought on by the presence of the spiders. In this situation Solidago is suppressed by the grasshoppers and consequently less carbon is stored in the ecosystem.

Conversely, when active hunting spiders are the dominant predator there are fewer predator-prey encounters, meaning the grasshoppers are less stressed. In this situation the insects prefer to feed on grasses over Solidago. The herb, with its relatively higher carbon content, is allowed to flourish and dominates the plant community. The researchers found that shifting from a dominance of sit-and-wait predators to a dominance of active hunting predators could potentially result in the soil retaining twice as much carbon. With grasslands covering around 40 percent of the Earth's terrestrial surface, the presence (and balance) of predators within such ecosystems could therefore have a marked influence on carbon cycling.

Today, predator populations continue to be degraded throughout most of the Earth's ecosystems. A range of studies in both terrestrial and aquatic environments - involving both vertebrate and invertebrate wildlife species - show that predator losses and their cascading effects can negatively impact the capacity of ecosystems to sequester atmospheric CO2.

On the northeastern coast of the US, for example, overfishing of predatory fish such as striped bass has led to the proliferation of herbivorous burrowing crabs. This, in turn, has resulted in the runaway consumption of saltmarsh vegetation, reducing its capacity to sequester blue carbon. And on the southeastern coast of the US, predatory blue crabs help to control the abundance of herbivorous periwinkle snails, which also graze saltmarshes. It has been shown that saltmarsh productivity is nearly ten times higher in the presence of blue crabs, significantly enhancing its capacity to absorb carbon and store it in saltmarsh sediment.

The global decline in predators - and wildlife populations in general - is worrying. Yet their critical role in governing the global carbon cycle also offers hope. The very significance of animals in the cycle means that protecting, restoring and managing biodiversity is a feasible, immediate and potentially game-changing way of managing the global carbon budget and addressing climate change.

10X

more carbon is stored in saltmarshes with the presence of predatory crabs

CASE STUDY:5

Musk oxen:
Arctic climate influencers

Research has shown that grazing by musk oxen and other large herbivores could have a significant impact on Arctic greenhouse gas exchange.

Photo details & credit: Musk oxen, Norway. Photo by Neil Burton.

Arctic ecosystems, which contain huge amounts of carbon in their soils, are of great significance to global greenhouse gas exchange. While the Arctic region has generally acted as a carbon sink for the past 10,000 years, the impact of climate change has recently seen some areas transition towards carbon source status. Herbivores are an important part of many Arctic ecosystems and have been found to have an important impact on the carbon cycle in the region, mainly through their grazing.

One of these herbivores is the musk ox, a large bovine noted for its thick coat, curved horns and the strong odour emitted by males during the seasonal rut (hence its name). Well-adapted to life in the frozen north, musk oxen roam the tundra in search of roots, mosses, and lichens. In winter, they use their hooves to dig through snow to graze, while in summer they supplement their diet with Arctic flowers and grasses, often feeding near water. There are around 170,000 musk ox currently living across the circumpolar tundra, concentrated in Greenland and Canada. With the Earth's climate rapidly warming, their future is uncertain.

In a study carried out by Swedish and Danish researchers in Greenland between 2011 and 2013, musk oxen were deliberately excluded from test areas by fencing. After several years the research team saw that a species of moss had grown strongly in these non-grazed test areas, which had hindered the growth of plants important for the absorption of CO2 and the production of CH4 (methane). **This resulted in a 47 percent decrease in CO2 uptake and a 44 percent decrease in CH4 emissions.**

The research team calculated that the net effect of excluding musk oxen from the test areas was to halve the positive impact of those areas on global warming. Despite the fact that the areas still grazed by musk oxen released more CH4 - a far more potent greenhouse gas than CO2 - this was compensated for by higher CO2 absorption. While both grazed and ungrazed areas acted as carbon sinks, the removal of the musk oxen meant plants only absorbed half as much carbon during the growing season.

Future research will help to improve our understanding of how herbivory and associated processes influence the carbon cycle within the Arctic. Nevertheless, it is already clear that the removal of grazing and trampling by musk ox and other large herbivores from Arctic ecosystems could rapidly alter the composition and structure of vegetation, with associated impacts on greenhouse gas exchange. It is important that herbivore populations, and their conservation, are taken into account in Arctic climate models.

> **"The removal of the musk oxen meant plants only absorbed half as much carbon during the growing season."**

Photo details & credit: Musk oxen, Norway. Photo by Dalia Kvedaraite.

CASE STUDY:6

Sea otters:
Guardians of the kelp forest

By helping to control sea urchin populations, sea otters influence the amount of atmospheric carbon absorbed and stored by kelp. The decline of this iconic predator impairs our own ability to address global warming.

Photo details & credit:
Sea otter, Elkhorn Slough, California

The charismatic sea otter is found along the coasts of the Pacific Ocean in North America and Asia. An aquatic member of the weasel family, it spends most of its time in the water, but occasionally comes ashore to sleep or rest. Superbly adapted to a life at sea, it has webbed feet, water-repellent fur, and nostrils and ears that can fully close. Sea otters float in groups known as “rafts”, which typically contain between 10 and 100 animals, although researchers have seen rafts of more than 1,000 individuals floating together.

Sea otters, like other apex predators such as wolves, function at the top of the food chain, causing trophic cascades that affect the flow and storage of atmospheric carbon. One of their main prey species is the sea urchin - a spiky, globular echinoderm that can rapidly sweep across the seabed and consume entire forests of kelp. By keeping urchin populations in check, sea otters allow such forests to flourish and lock up more carbon.

Researchers estimate that coastal ecosystems, rich with marine plants such as mangroves and seagrass, sequester as much as 20 times more carbon per hectare than forests. Using carbon from the atmosphere to grow leafy structures underwater, kelp forests are indeed one of the most efficient absorbers of atmospheric CO2.

But unlike mangroves and seagrass, kelp usually grows near the shore in rocky and eroding conditions, where plant material cannot get buried. Instead, pieces of kelp are eventually transported to the deep sea, where the carbon can be sequestered in marine sediment, far removed from the atmosphere.

A 2012 study on North American sea otters found that kelp forests guarded by sea otters can absorb 12 times more CO2 than unguarded forests, with the marine mammals supporting the storage of up to 8.7 million tonnes of carbon by kelp every year. This roughly equates to the annual CO2 emissions of 4 million passenger cars, and means North American sea otters perform a carbon capture service worth up to US$400 million a year.

The results of the sea otter study suggest that predators can strongly influence the carbon cycle through top-down forcing and trophic cascades. The extent to which these effects can be extrapolated across species and global ecosystems is yet to be fully determined, but it is clear that the restoration of predator populations has the potential to significantly influence the concentration of atmospheric CO2.

Moreover, the role of the sea otter in mitigating climate change demonstrates how easily the benefits that humans derive from healthy ecosystems - such as carbon sequestration - can diminish as our own actions negatively impact biodiversity. Hunted to near extinction in the eighteenth and nineteenth centuries, sea otters are currently endangered across their range, with pollution and habitat loss major factors in their decline. A decline that impairs our own ability to address global warming.

12X

Kelp forests guarded by sea otters can absorb 12 times more CO2 than unguarded forests.

CASE STUDY:7

Sharks:

Apex predators boost marine carbon storage

"Studies have shown that changes to predator populations can have a significant impact on CO2 emissions"

Sharks influence the abundance and behaviour of their prey. This can have a significant impact on blue carbon levels.

There is growing evidence from a wide range of ecosystems that predators, via trophic cascades, play an important and potentially irreplaceable role in the carbon cycle. Studies have shown that changes to predator populations can have a significant impact on CO_2 emissions, carbon storage by plants, and carbon export from erosion.

Sharks are apex predators in aquatic environments, which means they prey on a wide range of species below them in the food web. Through direct consumption they restrict the abundance of other animals, which in turn reduces the impact of those animals on their food source. Sharks also affect the foraging behaviour and distribution of their prey species through fear. Both of these trophic cascade mechanisms have an impact on the marine carbon cycle.

Research carried out on Australia's Great Barrier has shown that sharks cruising near coral reef patches can alter the foraging behaviour of many herbivorous fish species. The perceived threat of predation causes these fish to feed heavily near the coral patches, where they can quickly take shelter should the need arise, but stops them from venturing further. This leads to the creation of so-called "grazing halos" - patches of seabed that are largely devoid of seagrasses and macroalgae. Thanks to reduced levels of vegetation, these halos were found to have 24 percent less carbon stored in their sediments than areas which experienced little or no grazing.

In Shark Bay, in Western Australia, tiger sharks have been found to control the behaviour and numbers of dugong (sea cows), which graze on roughly 40 kg of seagrass a day. By keeping the dugong population in check, and reducing grazing pressure, the sharks help seagrass meadows thrive, thereby boosting CO_2 uptake and storage. Seagrass captures carbon up to 35 times more quickly than tropical rainforests - even though it only covers a tiny fraction of the seafloor, it absorbs an astonishing 10 percent of the ocean's carbon each year.

35X

Seagrass captures carbon up to 35 times more quickly than tropical rainforests

These studies, and a growing range of others, highlight the need to conserve predator-prey dynamics to help maintain the critical role of marine vegetation and sediment in carbon sequestration. Sharks, just like sea otters, have a critical role to play in this regard.

Yet shark populations are currently in decline in the majority of marine ecosystems. In the Caribbean and Indonesia, for example, dwindling shark populations have led to overgrazing by herbivores such as sea turtles, which has seen the complete disappearance of seagrass in some areas. A recent assessment by the IUCN found that over a third of all shark and ray species are now threatened with extinction. Overfishing is the biggest threat, but loss of coastal habitat, loss of prey, and declining water quality are also contributing factors.

Photo details & credit: Tiger shark, Bahamas. Photo by Gerald Schömbs

CASE STUDY:8

Whales:
Earth’s giants drive oceanic carbon capture

In both life and death, whales play a critical role in the oceanic carbon cycle. Allowing the Earth’s whale population to recover could have a significant impact on global warming.

Photo details & credit:
Sperm whale, Indian Ocean, Mauritius.
Photo by Wonderful Nature.

Many proposed solutions to climate change, such as capturing carbon directly from the air and burying it deep in the earth, are complicated, costly, and unproven. What if nature offered us a “no-tech” alternative that was effective, economical, and available to scale up right now? Look no further than the mighty whale.

Whales, particularly baleen and sperm whales, are among the largest creatures on Earth. Their bodies act as massive stores of carbon, while their presence shapes the marine ecosystems in which they live. We may think of trees doing the lion’s share of the work absorbing CO2 from the atmosphere, but in the oceans, these iconic animals play a hugely important role in the carbon cycle.

The astonishing carbon capture potential of large whales can be attributed to both the way they live and the way they die (see infographic). Having accumulated an average of 30 tonnes of bodily carbon, these marine leviathans sink to the bottom of the ocean when their lives end. As their carcasses slowly decompose, the “blue” carbon inside them is gradually incorporated into marine sediment, removing it from the atmosphere for millennia.

A scientific study carried out in 2010 estimated that eight species of baleen whale - including the blue, humpback and minke whale - together carry 30,000 tonnes of carbon to the bottom of the ocean every year. The authors also estimated that if populations of these whales were restored to pre-whaling levels, this carbon sink would increase by 160,000 tonnes a year.

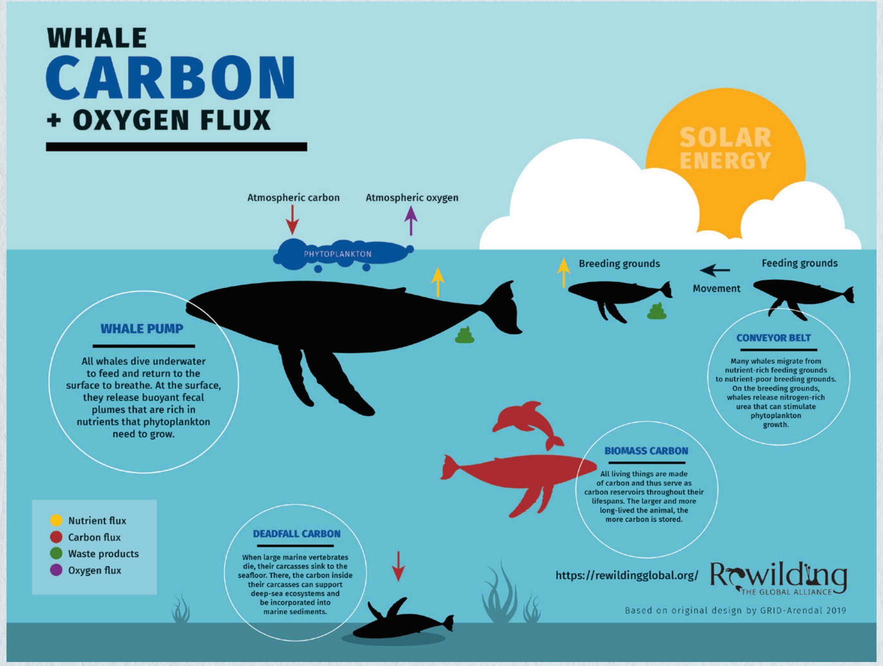
Whales not only store carbon in their bodies, but enhance the ocean’s ability to store carbon too. By swimming and diving, as well as defecating, whales increase the level of nutrients on the ocean surface - notably iron and nitrogen. This, in turn, boosts the growth of phytoplankton and marine plants, which removes carbon from the atmosphere. Studies have found that the 12,000 sperm whales of the Southern Ocean support the capture of an estimated 200,000 tonnes of carbon every year through this mechanism.

Today’s whale population of around 1.3 million animals is still recovering from commercial whaling, which was banned in 1986 (although some countries still flout the ban). The total pre-whaling population of whales has been estimated at 4 to 5 million, although genetic analysis of whale populations in the North Atlantic suggests it may have been four to five times greater than this. Regardless of the exact number, a continued whale comeback could significantly boost the amount of phytoplankton in the ocean and the atmospheric carbon it captures every year.

Researchers from the International Monetary Fund have estimated that a fully restored whale population may support the sequestration of more than 1.5 billion tonnes of CO2 every year. This is the equivalent of Russia’s annual anthropogenic CO2 emissions, or more than the annual anthropogenic CO2 emissions of the entire African continent. To reach this point, we simply need to let the Earth’s whale populations - which still face multiple threats - recover.

30k tonnes

Amount of carbon carried to the bottom of the ocean every year by 8 species of baleen whale



CASE STUDY:9

Wildebeest:

The fall and rise of an influential herbivore

On the plains of the Serengeti, the recovery of the wildebeest population has seen the landscape change from a net carbon source to a net carbon sink.

10%

Every time the wildebeest population increased by 100,000 animals, the area being burned reduced by around 10 percent.

Involving the movement of over one million animals, the annual wildebeest migration across East Africa's vast Serengeti grassland is one of the world's most awe-inspiring natural spectacles. It's hard to imagine such a herbivorous horde disappearing from the landscape. But this nearly happened in the first half of the twentieth century, when poaching and disease (the rinderpest virus) saw wildebeest numbers plummet to around 300,000.

The consequences of this collapse were profound. Much of the 25,000 square- kilometre Serengeti ecosystem was left ungrazed. The dead and dried grass that accumulated as a result became fuel for massive wildfires, which annually ravaged up to 80 percent of the area, making Kenya and Tanzania a significant regional source of CO_2 emissions. Over many years this state change also led to the loss of organic carbon from soil carbon stocks, as the entire Serengeti ecosystem became a net carbon source.

The situation changed in the late 1950s when a rinderpest vaccine eventually became available, leading to the effective eradication of the disease. This, combined with anti-poaching measures, saw the wildebeest population gradually recover to natural levels. More animals meant more grazing, which saw carbon shifted from above-ground combustible biomass to the soil via dung, thereby promoting carbon storage and reducing the incidence of wildfire. Every time the wildebeest population increased by 100,000 animals, the area being burned reduced by around 10 percent. More trees grew, storing more carbon.

Today, the impact of the restored wildebeest population on the Serengeti landscape means there are almost no wildfire outbreaks at all, while the rejuvenated grasslands now capture carbon up to the equivalent of the annual anthropogenic CO_2 emissions of Kenya and Tanzania combined. The Serengeti has become a carbon sink once again.

The case of the wildebeest in the Serengeti is just one example of how animals, and their presence or absence in a particular ecosystem, can impact the capacity of that ecosystem to store carbon. It also shows how the loss of just a single species can have far-reaching implications for ecosystems and climate. By being an integral part of a larger food chain - as wildebeest are - the presence or absence of such species may trigger knock-on effects that grow through the chain to drive significant amounts of carbon into long-term storage on land or in the ocean, or release it into the atmosphere.

"It shows how the loss of just a single species can have far-reaching implications for ecosystems and climate."

Photo details & credit: Migrating wildebeest, Maasai Mara National Park, Kenya

CASE STUDY:10

Wolves:
Pivotal predators

***By controlling herbivore populations, wolves could have a significant impact on the terrestrial carbon cycle*.**

Photo details & credit:
Gray wolf, Golden, British Columbia, Canada

Wild animals play a critical role in shaping ecosystems, with apex predators often having the greatest impact, despite their relatively modest population size. This happens because predators, herbivores, plants, and decomposers interact in complex food webs. While it has long been known that such webs support ecosystem resilience, it is now becoming clear that some trophic cascades could also have a significant impact on the carbon cycle and climate change.

As apex predators with an extensive geographical range, wolves could have a major influence on carbon sequestration. The carbon footprint of wolves depends on what they kill. This, in turn, depends on where they are living. A study carried out in 2016 examined the potential for wolves to have cascading effects on carbon cycling within two very different North American ecosystems: boreal forest inhabited by moose, and grassland inhabited by elk (wapiti).

The boreal forest of North America - a vast expanse of spruce, hemlock, pine and fir - is one of the most significant carbon-storing landscapes on the planet. Wolves have an outsized influence on the boreal ecosystem through their predation. Moose - as the dominant herbivore - also shape the composition of the forest, and microbes in the soil, because they feed heavily on shoots and leaves.

The 2016 study found that when healthy wolf populations are present in the boreal forest, they directly influence both the foraging behaviour and abundance of moose. This changes the way moose interact with boreal plant communities, which alters the forest composition and increases tree biomass. The end result is that wolves enhance carbon storage in both plants and soils.

By extrapolating their results, the study team estimated that wolves could (with a number of caveats) increase carbon storage in North American boreal forest by up to 99 million tonnes a year, compared to an ecosystem without wolves. The protection of wolf populations across the entire North American boreal region could therefore **safeguard the sequestration of carbon equivalent to 10 percent of CO2 emissions in the US.**

The situation in North American grasslands is very different, where the presence of wolves may actually decrease the amount of carbon stored in the landscape. Here, elk stimulate the growth of grass by excreting what they eat and fertilising the soil. In this scenario, an increase in the number of wolves may decrease the abundance of elk and thereby significantly suppress carbon storage. If wolves and elk co-existed across the entire expanse of North American high-altitude grassland, the 2016 study team estimated a loss of carbon storage of up to 30 million tonnes a year.

The study team subtracted the loss of carbon storage attributable to wolves throughout North American grasslands from the increase in carbon storage attributable to wolves in North American boreal forest. They found the potential net effect was of the same order of magnitude **as the removal of between 6 and 20 million passenger vehicles per year.** These figures are only estimates and far more research is required, but they indicate the scale of the potential impact of top predators on terrestrial ecosystem carbon cycling.

99 million

wolves could increase carbon storage in North American boreal forest by up to 99 million tonnes a year, compared to an ecosystem without wolves.

High potential species

The selection of case studies presented in this booklet showcase the significant and potentially game-changing influence of various wildlife species and trophic cascades on the global carbon cycle. Yet these case studies are merely scratching the surface - a huge range of animals the world over could be considered “high potential” in terms of their beneficial impact on carbon cycling, from mammals and birds to fish, reptiles and invertebrates. The majority of these require further research before the scale of their impact can be more accurately defined.

Dingoes in South Australia, for example, could impact the amount of carbon stored in plants and soil by controlling kangaroo populations. Where dingoes are absent, increasing populations of kangaroos can lead to overgrazing, reducing the capacity of the ecosystem to sequester carbon. And also in Australia, the huge decline in bogong moth numbers, which is likely caused by a combination of drought, pesticide use and light pollution, could have a massive impact on a whole range of wildlife species. As bogongs are nectar-eaters, it remains to be seen what the sudden loss of millions and millions of pollinating moths could have on the plants along their migration route - and the net effect on the carbon cycle.

“A huge range of animals the world over could be considered “high potential” in terms of their beneficial impact on carbon cycling”

In tropical Brazilian forests, fruit-eating tapirs, muriqui spider monkeys, howler monkeys, and black-fronted piping guan birds are important dispersers of seeds from tree species that have high carbon density - their behaviour thereby helps to enhance the carbon density of the entire forest. Frugivorous primates in Africa (such as chimps and bonobos) and Asia (such as gibbons) perform a similar seed dispersal role.

The rapid decline in the populations of such fruit eaters in tropical forests creates an urgent need to better understand the link between seed dispersal and carbon sequestration before these animals are irretrievably lost. Defaunation is already causing declines of large-seeded animal-dispersed trees in tropical forests worldwide - according to simulations, this is negatively impacting carbon sequestration.

Photo details & credit: Lowland tapir, Photo by Expedicionários Fotografia e Natureza

Also in the tropics, it has been shown that large, abundant reptiles are important in ecological processes and consequently have an important role in ecosystem function through gene dispersal, nutrient cycling, trophic action, and ecosystem engineering. Their role in mediating the carbon cycle needs to be further elucidated.

And in Africa, a good news story has seen leopard, wild dog and spotted hyena populations restored in Gorongosa National Park. Following years of civil war, the extirpation of these top predators had led to a “landscape of fearlessness”, with a lack of predation seeing herbivores graze on open grassland that was once considered too risky. Ongoing research will determine whether the reintroduction of these apex predators will lead to the restoration of trophic cascades that enhance plant production and carbon uptake.

Wild nature is resilient and will bounce back if we let it. It has been estimated, for example, that the world’s oceans could be restored within 30 years, if we take the right decisions. Further research into high-potential ACC species - in both terrestrial and aquatic ecosystems - can guide us as we take those decisions, ensuring that wildlife recovery not only benefits nature, but helps to address climate change at the same time.

“Wild nature is resilient and will bounce back if we let it”

Photo details & credit: The black-fronted piping guan, Brazil.

The way ahead

Nature is our ally

Many ecosystems - the basis of our natural wealth - are currently broken or severely degraded. Yet rewilding now offers an historic and unique opportunity to recover them and the essential wildlife populations they contain (or could contain). The fact that the global rewilding movement is rapidly gaining momentum is hugely encouraging. But we need to keep working hard to ensure the scaling up process continues, and to drive home the fact that recovering nature is the best way of simultaneously addressing both our climate and ecological emergencies.

Quantifying the impact of animal populations on carbon cycling is challenging due to the myriad indirect, multi-step pathways involved. Nevertheless, research has already shown that managing such populations for carbon storage stands to capture substantial global anthropogenic carbon emissions. As such, the animation of the carbon cycle can play a critical role in helping us to reach "net zero" emissions as quickly as possible and meet the 1.5˚C climate target.

Moving forward, the significant and potentially game-changing impact of wild animals on the carbon cycle will become increasingly relevant as scientists and policy-makers consider and advocate the use of nature-based climate solutions. To animate the carbon cycle, we can leverage a system already in place for new ends, with the potential to reframe the value ascribed to conservation. This means moving towards a world where animal populations are not simply protected and enhanced for their intrinsic or iconic value, but for the role they play in helping to regulate climate too.

"Today, we are learning more and more about the functional role that animal species play in carbon uptake and storage by ecosystems," says Oswald Schmitz. "At the same time, more and more species are in danger of disappearing forever. Conservation needs to change its focus from simply protecting and restoring these animals for their own sake and take consideration of their potential impact on climate change. When it comes to climate, animals offer us hope for the future, but only if we make the right decisions."

Amplifying and advancing ACC

Those already engaged with rewilding are ideally placed to spread the word about the importance of animating the carbon cycle and implementing and advancing the concept at both a practical and theoretical level. Please share this booklet and its main messages with your networks and wider conservation community. Reach out to key government decision makers responsible for negotiations on climate (UNFCCC), biodiversity (CBD), and fisheries, and inform them about the critical importance of ACC to reaching the 1.5oC climate target. Please feel free to extract those case studies relevant to your work and geographical area and communicate about them.

The number of "high potential" ACC wildlife species - animals with a particularly significant influence on the carbon cycle - is likely to be high, and they will be distributed widely across the globe. Please identify those already on the list that could play a critical role in your region, add others, and communicate about them too.

Far more research needs to be conducted into the impact of wildlife on the carbon cycle. Please reach out to members of the scientific community dealing with conservation and climate issues, share the main findings of this booklet and the science behind it, and encourage them to initiate their own ACC assessments and research. The development of an ACC-focused scientific network will ensure cross-pollination of ideas, help to validate theories, and advance the entire body of ACC science.

Last but not least, rewilding is characterised by its emphasis on practical action. The animation of the carbon cycle will require the restoration of nature on an unprecedented scale, with today's practical rewilding initiatives taking the lead, demonstrating the possibilities and benefits, and inspiring others to take similar action. As we all work towards a wilder world, please assess the possibility of integrating the ACC concept in your own conservation efforts. With the help of wildlife, we can keep 1.5 alive.

ACC for decision-makers

If we are to animate the carbon cycle to achieve the critically important 1.5˚C climate target, policy makers, scientists, NGOs, corporations, entrepreneurs, investors, philanthropists, and everyday citizens all have a role to play. Only by taking the right decisions and co-creating the right enabling environment can we restore wildlife populations on the necessary scale and timeframe.

Policy

Underpinned by the up-to-date science generated and provided by the initiative, specific reference should be made to the ACC in key climate change, biodiversity and international sea policy frameworks, such as the UNFCCC, CBD and UNCLOS.

Forests

Forest protection and restoration is currently the primary focus of nature-based climate solutions. Adding an ACC component could significantly enhance the carbon sink potential of such efforts. It is essential that we move away from tree planting and intensive, clear-cut forestry models. By promoting the natural regeneration of forests instead of tree planting, we could capture up to 40 times more carbon. As such, transitioning existing, managed forests into ecosystems which more closely characterise intact natural forests - a process known as "proforestation" - represents one of the most cost-effective solutions to the dual global crises of climate change and biodiversity loss.

Grasslands

Grasslands cover around 40 percent of the Earth's terrestrial surface and store more than 30 percent of land-based carbon, but are still largely ignored in considerations of nature-based climate solutions. Since sparsely grazed and natural grasslands account for 80 percent of the total cumulative grassland carbon sink (around 1 $GtCO_2$ equivalent annually), the future management, protection and restoration of these areas is critically important to the carbon cycle. Restoring large herbivores at historic baseline densities has the potential to significantly speed up the carbon mitigation process and reduce the risk of catastrophic wildfire.

Fishing

Fish play a critically important role in the global carbon cycle. With an urgent need for more and larger fish, a climate/ACC dimension must be incorporated when identifying fishing quotas, while no-take fishing zones must become compulsory when implementing the 30 x 30 protected area target for oceans.

National implementation

ACC should be incorporated in Nationally Determined Contributions (NDCs) and National Biodiversity Strategies and Action Plans (NSAPs).

Funding

Dedicated funding for rewilding/ACC implementation must be agreed at both national and international levels, for example through the Green Climate Fund.

New research

To increase our understanding of the critical importance of ACC to climate change mitigation and biodiversity conservation efforts, dedicated funding should be allocated in national and international research programmes.

Innovative financing

Credible carbon financing mechanisms for ACC should be launched with investments providing guarantees for the maintenance of ecosystem services "in perpetuity", as well as the local stewardship of natural assets.

Private sector

The private sector should ramp up its support for the implementation of rewilding/ACC measures on land and in the sea, building on the principles outlined under "innovative financing".

Rewilding THE GLOBAL ALLIANCE

Thank you!

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