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ZSL

LET'S WORK FOR WILDLIFE

Living Planet Report

2018: Aiming higher

Institute of Zoology (Zoological Society of London)
Founded in 1826, the Zoological Society of London (ZSL) is an international scientific, conservation and educational organization. Its mission is to achieve and promote the worldwide conservation of animals and their habitats. ZSL runs ZSL London Zoo and ZSL Whipsnade Zoo; carries out scientific research in the Institute of Zoology; and is actively involved in field conservation worldwide. ZSL manages the Living Planet Index® in a collaborative partnership with WWF.

WWF
WWF is one of the world's largest and most experienced independent conservation organizations, with over 5 million supporters and a global network active in more than 100 countries. WWF's mission is to stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature, by conserving the world's biological diversity, ensuring that the use of renewable natural resources is sustainable, and promoting the reduction of pollution and wasteful consumption.

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Children dive into the sea at sunset, Funafuti, Tuvalu

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CONTENTS

Editors-in-Chief:
Monique Grooten and Rosamunde Almond (WWF-NL)

Editorial and Production Team: Lead Editor: Tanya Petersen **Teams:** Michael Alexander (WWF International), Stefanie Deinet (Zoological Society of London), Savriël Dilingh, Robin Freeman (Zoological Society of London), Barney Jeffries, Evan Jeffries, Natasja Oerlemans (WWF-NL), Isabelle Oostendorp (WWF International), Mark Wright (WWF-UK), Lucy Young (WWF-UK) and Holly Strand

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Winnie De'Ath (WWF International), Mike Barrett, (WWF-UK), Monique Grooten (WWF-NL), Margaret Kinnaird (WWF Kenya) Lin Li (WWF International), Deon Nel and Rebecca Shaw (WWF-US)

Authors:
Mike Barrett (WWF-UK), Alan Belward (European Commission Joint Research Centre), Sarah Bladen (Global Fishing Watch), Tom Breeze (University of Reading), Neil Burgess (UN Environment World Conservation Monitoring Centre - UNEP-WCMC), Stuart Butchart (BirdLife International), Harriet Clewlow (British Antarctic Survey and the University of Exeter), Sarah Cornell (Stockholm Resilience Centre), Andrew Cottam (European Commission Joint Research Centre), Simon Croft (Stockholm Environment Institute), Guiseppe de Carlo (WWF International), Luca de Felice (European Commission Joint Research Centre), Adriana De Palma (Natural History Museum, London), Stefanie Deinet (Zoological Society of London), Rod Downie (WWF-UK), Carel Drijver (WWF-NL), Bernadette Fischler (WWF-UK), Robin Freeman (Zoological Society of London), Owen Gaffney (Stockholm Resilience Centre), Alessandro Galli (Global Footprint Network), Paul Gamblin (WWF International), Michael Garratt (University of Reading), Noel Gorelick (Google Earth Engine), Jonathan Green (Stockholm Environment Institute), Monique Grooten (WWF-NL), Laurel Hanscom (Global Footprint Network), Samantha Hill (UN Environment World Conservation Monitoring Centre - UNEP-WCMC), Craig Hilton-Taylor (IUCN), Arwyn Jones (European Commission Joint Research Centre), Tony Juniper (WWF-UK), Huma Khan (WWF International), David Kroodsma (Global Fishing Watch), David Leclère (International Institute for Applied Systems Analysis), Ghislaine Llewellyn (WWF-Australia), Georgina Mace (University College London), Louise McRae (Zoological Society of London), Karen Mo (WWF-US), Jeff Opperman (WWF International), Alberto Orgiazzi (European Commission Joint Research Centre), Stuart Orr (WWF International), Pablo Pacheco (WWF International), Deng Palomares and Daniel Pauly (Sea Around Us, Institute for the Oceans and Fisheries, University of British Columbia), Jean-Francois Pekel (European Commission Joint Research Centre), Linwood Pendleton (WWF-US), Andy Purvis (Natural History Museum, London), Norman Radcliffe (British Antarctic Survey), Toby Roxburgh (WWF-UK), Bob Scholes (University of the Wittswatersrand, South Africa and IPBES Chair), Deepa Senapathi (University of Reading), John Tanzer (WWF International), Michele Thieme (WWF-US), Dave Tickner (WWF-UK), Pablo Tittonell (Natural Resources and Environment Program of INTA, Argentina), Phil Trathan (British Antarctic Survey), Piero Visconti (University College London and Zoological Society of London), Mathis Wackernagel (Global Footprint Network) Chris West (Stockholm Environment Institute) and Natascha Zwaal (WWF-NL)

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Living Planet Report

2018: Aiming higher

A NEW GLOBAL DEAL FOR NATURE AND PEOPLE URGENTLY NEEDED

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Few people have had the chance to find themselves on the cusp of a truly historic transformation. I passionately believe that this is where we stand today. Our planet is at a crossroads and we have the opportunity to decide the path ahead.

On one hand, we have known for many, many years that we are driving the planet to the very brink. This is not a doom and gloom story; it is reality. The astonishing decline in wildlife populations shown by the latest Living Planet Index – a 60% fall in just over 40 years – is a grim reminder and perhaps the ultimate indicator of the pressure we exert on the planet.

On the other hand, science has never been clearer about the consequences of our impact. There has never been more awareness – nor such rapidly increasing investment in finding solutions. Today, we have the knowledge and means to redefine our relationship with the planet. There is no excuse for inaction. We can no longer ignore the warning signs; doing so would be at our own peril. What we need now is the will to act – and act quickly.

The nature conservation agenda is not only about securing the future of tigers, pandas, whales and all the amazing diversity of life we love and cherish on Earth. It's bigger than that. Our day-to-day life, health and livelihoods depend on a healthy planet. There cannot be a healthy, happy and prosperous future for people on a planet with a destabilized climate, depleted oceans and rivers, degraded land and empty forests, all stripped of biodiversity, the web of life that sustains us all.

In the next years, we need to urgently transition to a net carbon-neutral society and halt and reverse nature loss – through green finance and shifting to clean energy and environmentally friendly food production. In addition, we must preserve and restore enough land and ocean in a natural state to sustain all life.

But we have two main problems. First, and perhaps the greatest, is the cultural challenge. For too long we have taken nature for granted, and this needs to stop. The second is economic. We can no longer ignore the impact of current unsustainable production models and wasteful lifestyles. These must be accounted for and addressed.

This is today's – and our generation's – greatest challenge and opportunity: for the first time, we can fully grasp how protecting nature is also about protecting people. The environmental and human development agendas are rapidly converging.

Few people have the chance to be a part of truly historic transformations. This is ours. We have before us a rapidly closing window for action and an unparalleled opportunity as we head into the year 2020. This is when the world will review its progress on sustainable development by means of the Sustainable Development Goals, the Paris Agreement and the Convention on Biological Diversity. And this is when the world should embrace a new global deal for nature and people, as we did for climate in Paris, and truly demonstrate the path we are choosing for people and the planet.

Today, we still have a choice. We can be the founders of a global movement that changed our relationship with the planet, that saw us secure a future for all life on Earth, including our own. Or we can be the generation that had its chance and failed to act; that let Earth slip away. The choice is ours. Together we can make it happen for nature and for people.

Marco Lambertini,

Director General
WWF International

EXECUTIVE SUMMARY

Everything that has built modern human society is provided by nature and, increasingly, research demonstrates the natural world's incalculable importance to our health, wealth, food and security.

All economic activity ultimately depends on services provided by nature, estimated to be worth around US$125 trillion a year. As we better understand our reliance on natural systems it's clear that nature is not just a 'nice to have'. Business and the finance industry are starting to question how global environmental risks will affect the macroeconomic performance of countries, sectors and financial markets, and policy-makers wonder how we will meet climate and sustainable development targets with declining nature and biodiversity.

AS WE BETTER UNDERSTAND OUR RELIANCE ON NATURAL SYSTEMS IT'S CLEAR THAT NATURE IS NOT JUST A 'NICE TO HAVE'

Exploding human consumption is the driving force behind the unprecedented planetary change we are witnessing, through the increased demand for energy, land and water. Consumption indicators – such as the Ecological Footprint – provide a picture of overall resource use. The products we consume, the supply chains behind them, the materials they use and how these are extracted and manufactured have myriad impacts on the world around us.

CONSUMPTION IS THE DRIVING FORCE BEHIND THE UNPRECEDENTED PLANETARY CHANGE WE ARE WITNESSING, THROUGH THE INCREASED DEMAND FOR ENERGY, LAND AND WATER

While climate change is a growing threat, the main drivers of biodiversity decline continue to be the overexploitation of species, agriculture and land conversion. Indeed, a recent assessment found that only a quarter of land on Earth is substantively free of the impacts of human activities. This is projected to decline to just one-tenth by 2050. Land degradation includes forest loss; while globally this loss has slowed due to reforestation and plantations it has accelerated in tropical forests that contain some of the highest levels of biodiversity on Earth. Ongoing degradation has many impacts on species, the quality of habitats and the functioning of ecosystems. Two recent studies have focused on the dramatic reductions in bee and other pollinator numbers and on the risks to soil biodiversity, critical to sustain food production and other ecosystem services.

CURRENT RATES OF SPECIES EXTINCTION ARE 100 TO 1,000 TIMES HIGHER THAN THE BACKGROUND RATE, THE STANDARD RATE OF EXTINCTION IN EARTH'S HISTORY BEFORE HUMAN PRESSURE BECAME A PROMINENT FACTOR[1]

Marine and freshwater ecosystems are also facing huge pressures. Almost 6 billion tonnes of fish and invertebrates have been taken from the world's oceans since 1950. Plastic pollution has been detected in all major marine environments worldwide, from shorelines and surface waters down to the deepest parts of the ocean, including the bottom of the Mariana Trench. Freshwater habitats, such as lakes, rivers and wetlands, are the source of life for all humans yet they are also the most threatened, strongly affected by a range of factors including habitat modification, fragmentation and destruction; invasive species; overfishing; pollution; disease; and climate change.

Using big data, sophisticated imaging methods and a wave of other new tracking and analytical tools, researchers are matching commodities and their supply chains to specific impacts on biodiversity. Increasing the transparency around these complex relationships may help to stop biodiversity loss.

This global overview is useful but it's also important to understand whether there are differences in threats between different geographic regions and whether similar species are affected by them in different ways. The Living Planet Index, a rich source of this information, can tell us about threats at the species population level. This more granular level of data has already highlighted different responses in different species of penguins in western Antarctica.

BIODIVERSITY HAS BEEN DESCRIBED AS THE 'INFRASTRUCTURE' THAT SUPPORTS ALL LIFE ON EARTH. IT IS, SIMPLY, A PREREQUISITE FOR OUR MODERN, PROSPEROUS HUMAN SOCIETY TO EXIST, AND TO CONTINUE TO THRIVE

The Living Planet Index also tracks the state of global biodiversity by measuring the population abundance of thousands of vertebrate species around the world. The latest index shows an overall decline of 60% in population sizes between 1970 and 2014. Species population declines are especially pronounced in the tropics, with South and Central America suffering the most dramatic decline, an 89% loss compared to 1970. Freshwater species numbers have also declined dramatically, with the Freshwater Index showing an 83% decline since 1970. But measuring biodiversity – all the varieties of life that can be found on Earth and their relationships to each other – is complex, so this report also explores three other indicators measuring changes in species distribution, extinction risk and changes in community composition. All these paint the same picture – showing severe declines or changes.

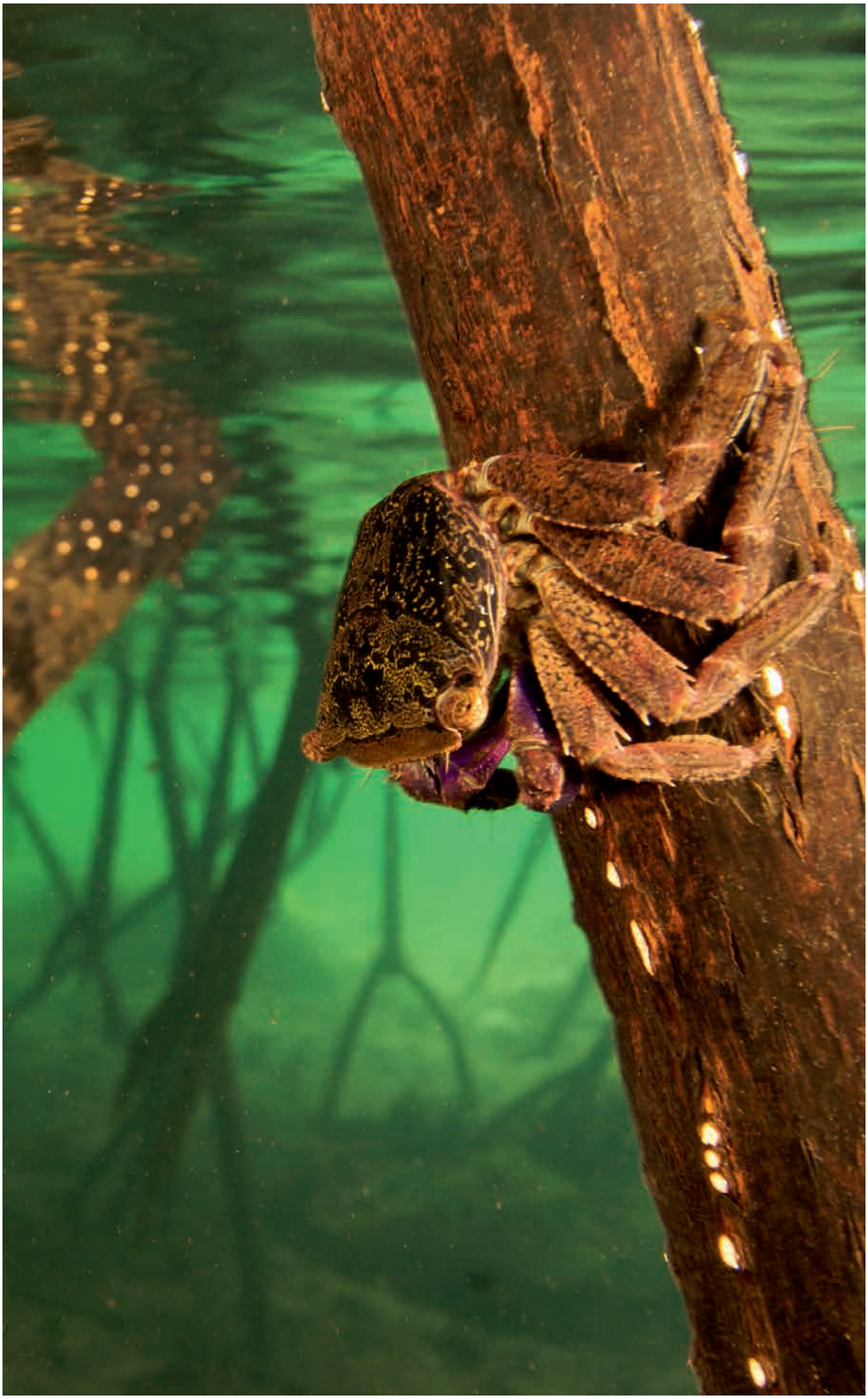
What is clear is that without a dramatic move beyond 'business as usual' the current severe decline of the natural systems that support modern societies will continue. With two key global policy processes underway – the setting of new post-2020 targets for the Convention on Biological Diversity and the Sustainable Development Goals – there is currently a unique window of opportunity to reverse the trend. Lessons can be learned from progress towards addressing other critical global issues, like climate change, and everyone – governments, business, finance, research, civil society and individuals – has a part to play.

WE ARE CALLING FOR THE MOST AMBITIOUS GLOBAL AGREEMENT YET – A NEW GLOBAL DEAL FOR NATURE AND PEOPLE

That's why we, along with conservation and science colleagues around the world, are calling for the most ambitious global agreement yet – a new global deal for nature and people. Decision-makers at every level need to make the right political, financial and consumer choices to achieve the vision that humanity and nature thrive in harmony on our only planet. This vision is possible with strong leadership from us all.

In our contribution to this ambitious pathway, WWF is collaborating with a consortium of almost 40 universities and conservation and intergovernmental organizations to launch the research initiative Bending the Curve of Biodiversity Loss. This critical work will explicitly include biodiversity in future systems modelling, helping us to determine the best integrated and collective solutions and to understand the trade-offs we may need to accept to find the best path ahead. These models and systems analyses will form the cornerstone of a future edition of the *Living Planet Report*.

WE ARE THE FIRST GENERATION THAT HAS A CLEAR PICTURE OF THE VALUE OF NATURE AND OUR IMPACT ON IT. WE MAY BE THE LAST THAT CAN TAKE ACTION TO REVERSE THIS TREND. FROM NOW UNTIL 2020 WILL BE A DECISIVE MOMENT IN HISTORY.



© naturepl.com - Tim Laman - WWF

A mangrove crab on the root of a red mangrove tree (*Rhizophora mangle*), just below the water line on Kostrae Island, Federated States of Micronesia.

SETTING THE SCENE

We live in an age of rapid and unprecedented planetary change. Indeed, many scientists believe our ever-increasing consumption, and the resulting increased demand for energy, land and water, is driving a new geological epoch: the Anthropocene. It's the first time in the Earth's history that a single species – *Homo sapiens* – has had such a powerful impact on the planet.

This rapid planetary change, referred to as the "Great Acceleration", has brought many benefits to human society. Yet we now also understand that there are multiple connections between the overall rise in our health, wealth, food and security, the unequal distribution of these benefits and the declining state of the Earth's natural systems. Nature, underpinned by biodiversity, provides a wealth of services which form the building blocks of modern society; but both nature and biodiversity are disappearing at an alarming rate. Despite well-meaning attempts to stop this loss through global agreements such as the Convention on Biological Diversity, we are failing; current targets and consequent actions amount, at best, to a managed decline. To achieve climate and sustainable development commitments, reversing the loss of nature and biodiversity is critical.

Since 1998 the *Living Planet Report*, a science-based assessment of the health of our planet, has been tracking the state of global biodiversity. In this landmark anniversary edition, 20 years after its original publication, the *Living Planet Report 2018* provides a platform for the best science, cutting-edge research and diverse voices on the impact of humans on the health of our Earth. More than 50 experts from academia, policy, international development and conservation organizations have contributed to this edition.

This growing collective voice is crucial if we are to reverse the trend of biodiversity loss. The extinction of a multitude of species on Earth seems not to have captured the imagination, or attention, of the world's leaders enough to catalyse the change necessary. Together, we are advocating the need for a new global deal for nature and people that addresses the crucial questions of how to feed a growing global population, limit warming to 1.5°C, and restore nature.

We are the first generation that has a clear picture of the value of nature and the grave situation we are facing. We may also be the last generation that can do something about it. We all have a role to play in reversing the loss of nature – but time is running out. Between now and 2020 we have a unique opportunity to influence the shape of global agreements and targets on biodiversity, climate and sustainable development – for a positive future for nature and people.

AT A GLANCE

Not just a 'nice to have'

CHAPTER 1

WHY BIODIVERSITY MATTERS

- Our health, food and security depend on biodiversity. From medical treatments to food production, biodiversity is critical to society and people's well-being.
- All our economic activity ultimately depends on nature. It's estimated that, globally, nature provides services worth around US$125 trillion a year.
- Stable planetary systems have enabled modern human society to develop. Without healthy natural systems researchers are asking whether continuing human development is possible.

A snapshot of threats

CHAPTER 2

THREATS AND PRESSURES

- Overexploitation and agricultural activity, driven by our runaway consumption, are still the dominant causes of current species loss.
- Land degradation seriously impacts 75% of terrestrial ecosystems, reducing the welfare of more than 3 billion people, with huge economic costs.
- Bees, other pollinators and our soils – critical for global food security – are under increasing threat.
- Overfishing and plastic pollution are threatening our oceans, while pollution, habitat fragmentation and destruction have led to catastrophic declines in freshwater biodiversity.
- New technologies and big data are helping us to understand and measure these threats and their specific impacts.

The 2018 Living Planet Index

CHAPTER 3

BIODIVERSITY IN A CHANGING WORLD

- The Living Planet Index has recorded an overall decline of 60% in species population sizes between 1970 and 2014.
- The Living Planet Index shows species population declines are especially pronounced in the tropics, with South and Central America suffering an 89% loss compared to 1970.
- A Freshwater Living Planet Index shows an 83% decline since 1970.

Biodiversity 2050

CHAPTER 4

WHAT FUTURE DO WE WANT?

- Despite multiple international policy agreements and extensive research biodiversity is still in decline.
- More ambition is needed to not simply halt loss but to reverse the trend of biodiversity decline.
- The CBD 2050 vision is that *"biodiversity is valued, conserved, restored and wisely used, maintaining ecosystem services, sustaining a healthy planet and delivering benefits essential for all people"*.
- Conservation scientists propose a 2020-2050 'blueprint for biodiversity': a vision for the future through the Convention on Biological Diversity.
- Scenarios and indicators can help imagine the future and create good policies and monitor progress.

CHAPTER 1:
Why biodiversity matters

Everything that has built modern human society, with its benefits and luxuries, is provided by nature – and we will continue to need these natural resources to survive and thrive. Increasingly, research demonstrates nature's incalculable importance to our health, wealth, food and security. What future benefits might we discover in the millions of species yet to be described, let alone studied? As we better understand our reliance on natural systems it's clear that nature is not just a 'nice to have'.

A butterfly rests on a branch in Kaya Kauma forest. Kilifi, Kenya.


© Greg Armfield - WWF-UK

THE IMPORTANCE OF NATURE TO OUR LIVES

Tony Juniper, WWF

Humans have evolved, grown and thrived, in nature. In fact, nature – and everything that it gives us – has been the catalyst for where we are today. Its resources have enabled people to dominate the planet complete with modern expectations, benefits and luxuries. To sustain modern human society we will continue to need the resources of nature that, throughout history, have allowed us to thrive.

While this dependence on nature is self-evident to many, important decisions made in boardrooms, finance ministries and presidential offices rarely reflect this. Indeed, the perception that lies behind so many environmentally damaging choices is that nature is a 'nice to have' and its protection is secondary to the more important tasks of increasing economic growth, creating jobs, enhancing the competitiveness of industry or keeping prices low.

NATURE IS OF INCALCULABLE IMPORTANCE TO OUR HEALTH, WEALTH AND SECURITY

At last this is beginning to change. Many companies and governments are now signalling their intention to adopt more integrated approaches, striving to protect or enhance nature while also pursuing all of their other goals. This shift in perspective is still in its infancy, but is based on an increasingly strong body of evidence illustrating nature's incalculable importance to so many aspects of our lives, including our health and wellbeing, food supply, wealth and security.

First, our health. Many medical treatments have been inspired by wild species, from painkillers to treatments for heart conditions and from cancer cures to remedies for high blood pressure[1].

TO SUSTAIN MODERN HUMAN SOCIETY WE WILL CONTINUE TO NEED THE RESOURCES OF NATURE

The IUCN Medicinal Plants Specialist Group estimates that there are between 50,000 and 70,000 known medicinal and aromatic plants used industrially[2]. Some of them are key to drug discovery and could be vital in finding the next blockbuster treatment. For example, at least 70% of new small molecule drugs introduced worldwide over the past 25 years have come from, or have been inspired by, a natural source[2,3].

Small molecules make up the bulk of new drug candidates since they target enzymes or receptors on the body's cells more accurately and specifically than large molecules like antibodies or proteins [4]. Scientists fear that biodiversity loss diminishes the supplies of raw materials for drug discovery and biotechnology [5].

Other research increasingly shows that being in natural areas improves our physical wellbeing, through encouraging outdoor exercise [6], and there is a growing body of evidence to show that time in nature can help to maintain and promote psychological wellbeing [7].

Equally fundamental to our wellbeing is nutrition. All our food, in the end, relies one way or another on natural systems, including the complex ecological relationships that enable soils to support plant growth. About 87% of all flowering plant species are pollinated by animals [8], and crops that are partially pollinated by animals account for 35% of global food production [9]. This is explored further in Chapter 2. Then, of course, there is the water that not only sustains all our agriculture but also all industry.

While it is sometimes easy to assume that water security is assured primarily via dams, reservoirs, treatment works and distribution networks, it is in the end nature that replenishes the freshwater that underpins all economic activity. Rainforests pump moisture into the atmosphere and the 'sky rivers' that flow from them water crops thousands of kilometres away from where they stand [10]. Wetlands purify water and recharge the aquifers from which springs flow. Natural systems also contribute to water security through the role they play in maintaining climatic stability [11]. Water ecosystems are explored further in the next chapter.

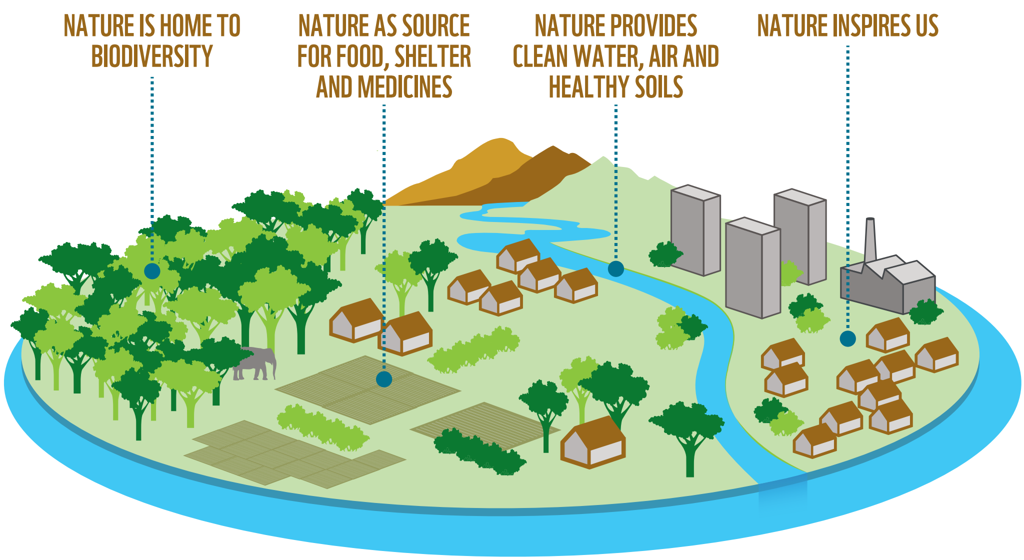
As climate change intensifies, nature's value is only increasing. It will play an essential role in helping human societies cope with the inevitable consequences of rising global temperatures. These include rising sea levels, more extreme rainfall, more frequent droughts and more frequent and intense storms – all impacts that NATO and the Pentagon recognize as significant threats to global security. Healthy natural systems can help reduce the damage caused by these changes [12,13].

On top of all these benefits is the immense importance of the plants and animals found in healthy natural and semi-natural systems. Wild animals, plants, fungi and microbes have underpinned human wellbeing throughout our entire existence; increasingly wildlife is being harnessed for so-called biomimicry, as engineers and designers use solutions honed by natural selection to meet challenges in the human world, including in relation to resource efficiency and renewable energy [14].

The incalculable potential future value of benefits we might derive from further discoveries based on natural diversity will only be possible so long as ecosystems can continue to sustain the vast range of species that share the world with us. This includes the millions that have yet to be described, let alone studied [15].

In our modern, urban world, we are often removed from day-to-day contact with natural areas. The spiritual, intrinsic, aesthetic and scientific cases for the protection and restoration of nature can seem remote or to have little immediate relevance. But as it becomes more widely recognized that natural systems underpin our health, wealth and security the impetus to protect and restore nature is much more powerful. If successful, we would be the first generation to accomplish such a change in direction.

Figure 1: The importance of nature to people
Nature provides us with vital goods and services. Adapted from Van Oorschot et al., 2016 [16].



All economic activity ultimately depends on services provided by nature, making it an immensely valuable component of a nation's wealth. It's estimated that, globally, nature provides services worth around US$125 trillion a year. Governments, business and the finance sector are starting to question how global environmental risks – such as increasing pressure on agricultural land, soil degradation, water stress and extreme weather events – will affect the macroeconomic performance of countries, sectors and financial markets.

THE IMPORTANCE OF NATURE TO THE WORLD'S ECONOMIES

Toby Roxburgh,
WWF

From the supply of raw materials, water, food, medicines and energy, to the pollination of crops, formation of soils and protection from floods, storms and erosion, the planet's natural systems provide a range of vital services that underpin production, trade, livelihoods and consumption in every country (figure 1).

The natural assets that provide these services – ecosystems, species, water, rivers, seas, land, minerals and atmosphere – are thus an immensely valuable component of a nation's wealth, and a major factor in determining its levels of economic prosperity.

In 2018, under the auspices of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) – an organization established to assess the state of biodiversity and the ecosystem services it provides to society – more than 550 leading experts from more than 100 countries attached numbers to the value of specific aspects of nature. These cutting-edge assessments go beyond the ecosystem service concept used in the landmark 2005 Millennium Ecosystem Assessment [17], additionally recognizing the central role that culture plays in defining all links between people and nature [18]. The IPBES Conceptual Framework – which underpins all its assessments and syntheses – calls this much broader notion Nature's Contribution to People, shortened to NCP [18,19].

It takes valuing nature beyond simply assigning a dollar figure and recognizes other knowledge systems, for example those of local communities and indigenous peoples. Sir Robert Watson, the Chair of IPBES, highlights the multifaceted nature of this approach: "This new inclusive framework demonstrates that while nature provides a bounty of essential goods and services, such as food, flood protection and many more, it also has rich social, cultural, spiritual and religious significance – which needs to be valued in policymaking as well."[20]

The result of three years' work, these extensively peer-reviewed reports cover the entire planet except the poles and the open oceans[21-24] and focus on providing answers to some key questions, including: why is biodiversity important, where are we making progress, what are the main threats and opportunities for biodiversity, and how can we adjust our policies and institutions for a more sustainable future?

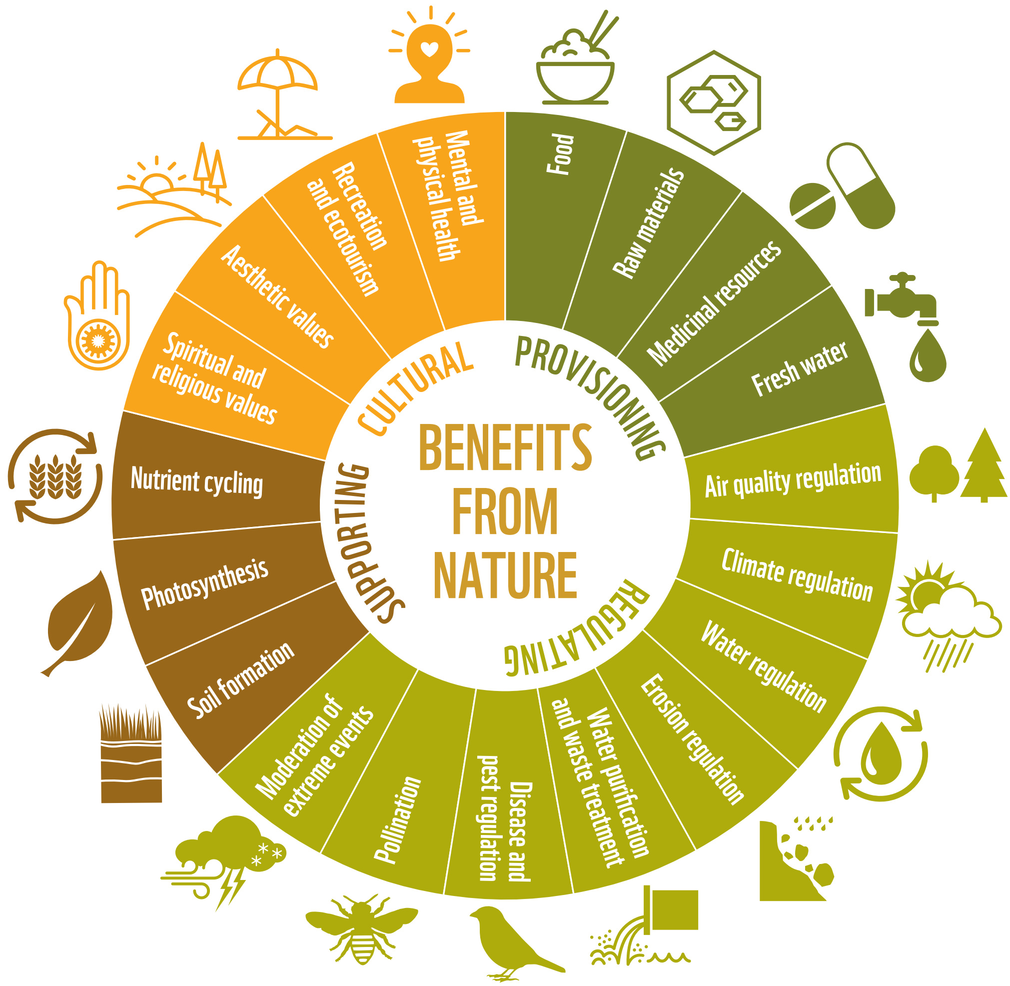
The Americas regional report, for example, put the economic value of nature's land-based benefits there alone at more than US$24 trillion per year – equivalent to the region's gross domestic product (GDP)[21]. However, it says 65% of these contributions are in decline, with 21% declining strongly. Another report estimates that, at the global level, nature provides services worth at least US$125 trillion per year[25]. What is clear is that in every region, biodiversity and nature's capacity to contribute to people is being degraded, reduced and lost due to a number of common pressures – habitat stress; overexploitation and unsustainable use of natural resources; air, land and water pollution; increasing numbers and impact of invasive alien species; and climate change, among others.

These concerns dominated the World Economic Forum 2018 Global Risks Report[26]. Political and business leaders, and the finance sector, are starting to question how global environmental trends – such as increasing pressure on agricultural land, soil degradation, water stress and extreme weather events – will affect the macroeconomic performance of countries and sectors, and how this will play out in financial markets[27]. The report is evidence that changing planetary conditions are increasingly linked to major socio-economic disruptions.

Figure 2: Benefits from nature
Provisioning services are the products obtained from ecosystems, regulating services are the benefits obtained from the regulation of ecosystem processes, cultural services are the nonmaterial benefits people obtain from ecosystems and supporting services are those services that are necessary for the production of all other ecosystem services. Adapted from the Millennium Ecosystem Assessment, 2005[17].

"NATURE UNDERPINS EVERY PERSON'S WELLBEING AND AMBITIONS – FROM HEALTH AND HAPPINESS TO PROSPERITY AND SECURITY"[20]

SIR ROBERT WATSON, CHAIR OF IPBES



"BIODIVERSITY AND NATURE'S CONTRIBUTIONS TO PEOPLE SOUND, TO MANY, ACADEMIC AND FAR REMOVED FROM OUR DAILY LIVES. NOTHING COULD BE FURTHER FROM THE TRUTH – THEY ARE THE BEDROCK OF OUR FOOD, CLEAN WATER AND ENERGY. THEY ARE AT THE HEART NOT ONLY OF OUR SURVIVAL, BUT OF OUR CULTURES, IDENTITIES AND ENJOYMENT OF LIFE. THE BEST AVAILABLE EVIDENCE, GATHERED BY THE WORLD'S LEADING EXPERTS, POINTS US NOW TO A SINGLE CONCLUSION: WE MUST ACT TO HALT AND REVERSE THE UNSUSTAINABLE USE OF NATURE – OR RISK NOT ONLY THE FUTURE WE WANT, BUT EVEN THE LIVES WE CURRENTLY LEAD. FORTUNATELY, THE EVIDENCE ALSO SHOWS THAT WE KNOW HOW TO PROTECT AND PARTIALLY RESTORE OUR VITAL NATURAL ASSETS."[28]

Sir Robert Watson, Chair of IPBES

CHILDREN AND NATURE

1. The school of natural healing

In Santa Rosa de Huacaria, which borders the Manu National Park in Peru, Veronica Alata and her students study medicinal plants with the help of the Huachipaeri indigenous community. In this image they are learning about the Pinon Colorado plant (*Jatropha gossypifolia*, a Euphorbiaceae) whose resin is used to treat insect bites and intestinal infections. A bath steeped with the leaves relieves headaches and fevers, and the seeds are strongly purgative. This community is part of the WWF/Pro Naturaleza project. Education is an important component in many nature conservation programmes around the world, teaching children the dynamics of natural processes and the different services that nature provides.


© André Bärtschi - WWF

We are living through the Great Acceleration – a unique event in the 4.5 billion-year history of our planet – with exploding human population and economic growth driving unprecedented planetary change through the increased demand for energy, land and water. This is so great that many scientists believe we are entering a new geological epoch, the Anthropocene. Yet the human benefits of the Great Acceleration have only been possible with nature. Without healthy natural systems we need to ask whether future human development is even possible.

THE GREAT ACCELERATION

Owen Gaffney,
Stockholm Resilience Centre
and Future Earth

In 2016, Max Roser from the University of Oxford carried out a thought experiment: imagine if the 24-hour news cycle fell silent. Instead news came out once every 50 years[29]. Now we can ask: what would the 2018 headline be? The end of the Cold War? The rise of neoliberalism? The internet? Civil rights? The financial crisis? Probably none of these.

The biggest single phenomenon in the last 50 years is barely discussed in the media, politics, business or education circles. It is the Great Acceleration – a unique event in the 4.5 billion-year history of our planet (see figure 3). Since 1800, global population has grown sevenfold, surpassing 7.6 billion, and the global economy has grown 30-fold[30]. But it has really been in the last 50 years that economic development has driven a phenomenal increase in the demand for energy, land and water that is fundamentally changing Earth's operating system.

It is economic development and the growth of the world's middle classes, not population rise per se, that is dramatically influencing the rate of change of Earth's life support system[30,31]. This growth has improved the lives of billions of people. Global average life expectancy is over 70[32]. Diseases such as smallpox have been eradicated and others look set to follow soon: mumps, measles, rubella, polio. More children reach adulthood and fewer women die during childbirth. Poverty is at an historic low. All this we should celebrate.

However, these exponential health, knowledge and standard-of-living improvements of the Great Acceleration have come at a huge cost to the stability of the natural systems that sustain us (figure 1). Our impact has now reached a scale at which it interferes profoundly with Earth's atmosphere, ice sheets, ocean, forests, land and biodiversity [33]. Greenhouse gas emissions have risen at alarming rates [34,35] and in April 2018, levels of carbon dioxide in the atmosphere reached an average of 410 parts per million (ppm) across the entire month – the highest level in at least 800,000 years [36]. Above Antarctica, it was discovered in 1985 that manufactured chemicals had created a vast hole in the ozone layer [37]. Rainforests are shrinking: almost 20% of the Amazon, referred to as the lungs of the planet, has disappeared in just 50 years [38].

From Holocene to Anthropocene

At the end of the last ice age, the Earth entered a new geological epoch – the Holocene [39]. This remarkably stable warm period has lasted about 11,700 years and we might expect it to continue for another 50,000 – but the Great Acceleration changes all that [40]. Human-induced change is so great that many scientists believe we are entering a new geological epoch: the Anthropocene [41].

ANTHROPOCENE: THE CURRENT GEOLOGICAL EPOCH CHARACTERIZED BY PLANETARY UPHEAVAL. THIS IS THE FIRST TIME IN EARTH'S HISTORY THAT A SINGLE SPECIES – HOMO SAPIENS – HAS HAD SUCH A POWERFUL EFFECT ON EARTH'S LIFE SUPPORT SYSTEM

It is not known whether a stable Anthropocene state will come to exist [42]. It certainly isn't stable now [31]. In the last 50 years, global average temperature has risen at 170 times the background rate [31]. Ocean acidification may be occurring at a rate not seen in at least 300 million years [43]. Earth is losing biodiversity at a rate seen only during mass extinctions [44]. And still more change may be headed our way as people are responsible for releasing 100 billion tonnes of carbon into the Earth system every 10 years [45].

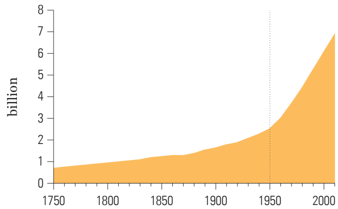
So what does this mean for the Earth? So far it looks like warm-water coral reefs – the most diverse of marine habitats – may not make it to the end of the century [46]. Without colossal action to reduce emissions, the Arctic is likely to be ice-free in summer before mid-century [47]. Ice reflects heat into space, but as it melts it exposes more dark waters that absorb heat. Researchers are concerned this could set up a dangerous feedback loop, amplifying warming. New research is also linking changes in the Arctic to a major shift in the jet stream that influences weather in the northern hemisphere [48]. This can influence drought in California [49], deep freezes on the eastern coast of the US and across Europe, and the trajectory of hurricanes. Early analysis indicates it contributed to the unprecedented heatwave across the northern hemisphere in 2018 [50].

HUMAN DEVELOPMENT AND EARTH'S SYSTEMS

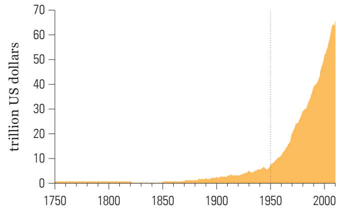
The Great Acceleration, and the rapid and immense social, economic and ecological changes it has spurred, show us that we are in a period of great upheaval. Some of these changes have been positive, some negative, and all of them are interconnected. What is increasingly clear is that human development and wellbeing are reliant on healthy natural systems, and we cannot continue to enjoy the former without the latter.

SOCIO-ECONOMIC TRENDS

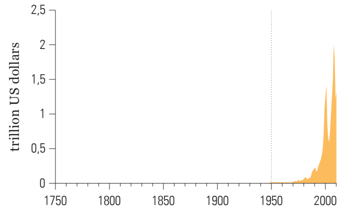
WORLD POPULATION



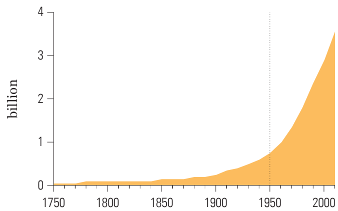
REAL GDP



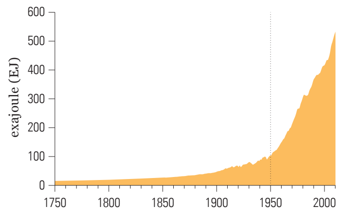
FOREIGN DIRECT INVESTMENT



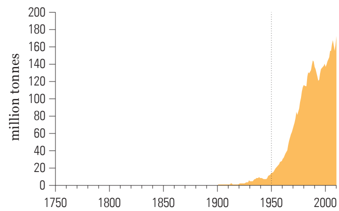
URBAN POPULATION



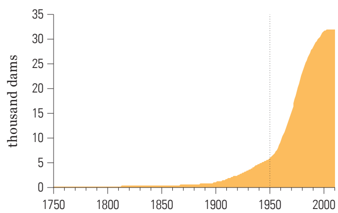
PRIMARY ENERGY USE



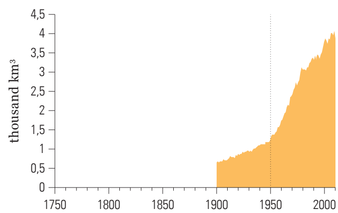
FERTILIZER CONSUMPTION



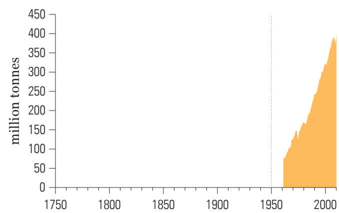
LARGE DAMS



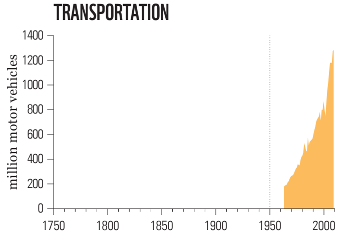
GLOBAL WATER USE



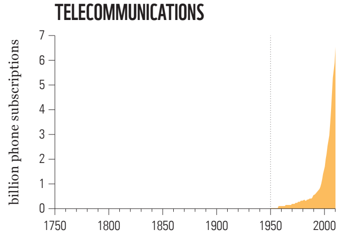
PAPER PRODUCTION



TRANSPORTATION



TELECOMMUNICATIONS

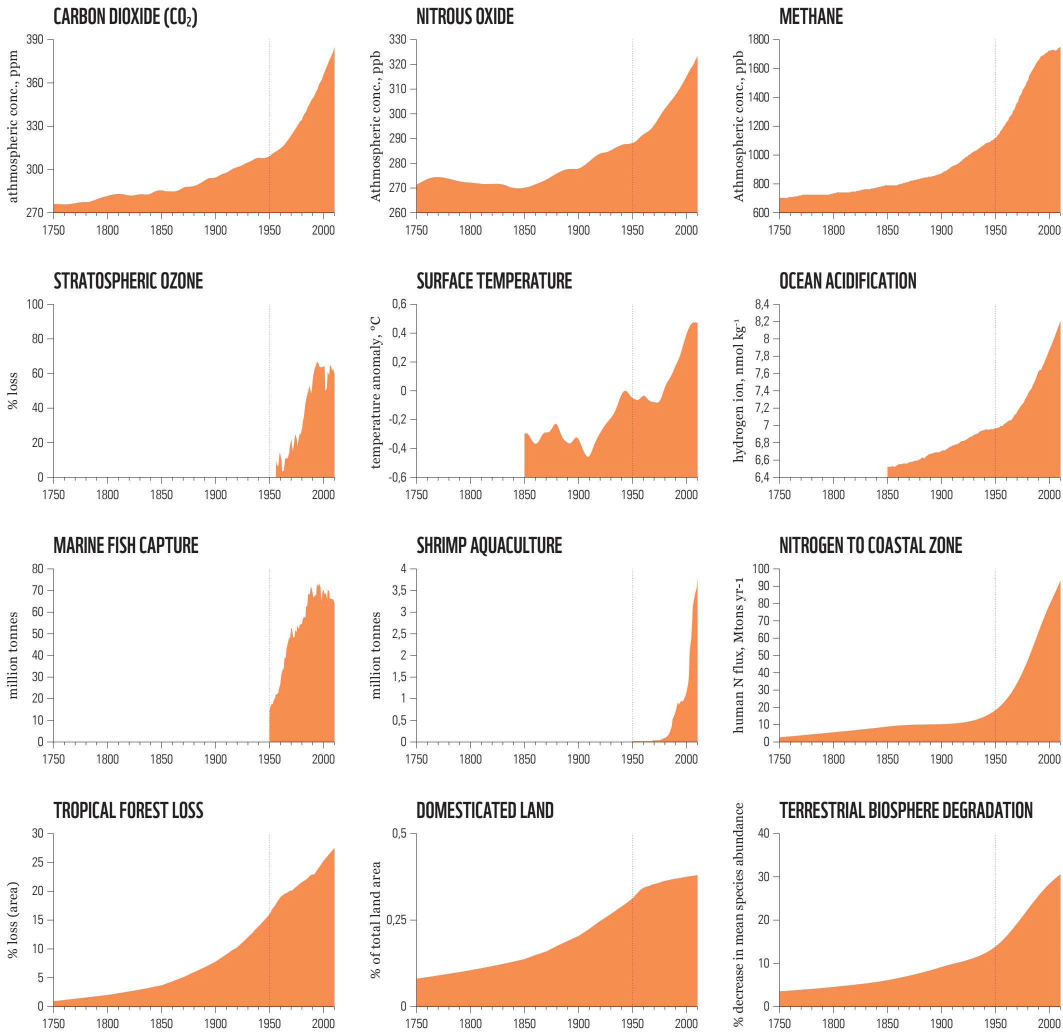


INTERNATIONAL TOURISM

Figure 3: The Great Acceleration

The increasing rates of change in human activity since the beginning of the Industrial Revolution. The 1950s marks an explosion in growth. After this time, human activities (left panels) begin to interfere significantly with Earth's life support system (right panels) (these graphs are from Steffen et al., 2015[30] and all the references to the datasets behind them are in the original paper).

EARTH SYSTEM TRENDS



CHAPTER 2:
The threats and pressures wiping out our world

Understanding that Earth's natural systems are critical in maintaining our modern human society means piecing together the biggest threats to nature so that we can better protect it. Climate change is certainly a growing threat, but today, the main drivers of biodiversity decline continue to be the overexploitation of species, agriculture and land conversion – all driven by runaway human consumption. Researchers are developing sophisticated new tracking and analytical tools to match commodities and their supply chains to specific impacts on biodiversity, and increasing the transparency around these complex relationships may help to stop biodiversity loss.

Aerial view of oil palm plantation. Sungai Petani vicinity, Kedah, Malaysia.

© naturepl.com - Tim Laman - WWF

THREATS OLD AND NEW

In a recent paper, researchers writing in the journal *Nature* analysed the most prevalent threats facing more than 8,500 threatened or near-threatened species on the IUCN Red List (explored in detail in Chapter 3)[1]. They found that the key drivers of biodiversity decline remain overexploitation and agriculture. Indeed, of all the plant, amphibian, reptile, bird and mammal species that have gone extinct since AD 1500, 75% were harmed by overexploitation or agricultural activity or both.

OF ALL SPECIES THAT HAVE GONE EXTINCT SINCE AD1500, 75% WERE HARMED BY OVEREXPLOITATION OR AGRICULTURE

Beyond overexploitation and agriculture, invasive species are another frequent threat, their spread relying heavily on trade-related activities such as shipping. Pollution and disturbance, for example through agricultural pollution, dams, fires and mining, are additional sources of pressure. Climate change is playing a growing role and is already beginning to have an effect at an ecosystem, species and even genetic level[2]. However, according to the IUCN Red List data, whatever the threat category or the species group, overexploitation and agriculture are the 'big killers' with the greatest current impact on biodiversity.

Overexploitation and ever-expanding agriculture are driven by spiralling human consumption. Over the past 50 years our Ecological Footprint – a measure of our consumption of natural resources – has increased by about 190%[3]. Creating a more sustainable system will require major changes to production, supply and consumption activities. For this we need a detailed understanding of how these complex components link together, and the actors involved, from source to shelf, wherever they may be on the planet.

This chapter explores the impacts that consumption, overexploitation and agriculture are having on land and forests, in our oceans and on our precious freshwater reserves. It also looks at some cutting-edge initiatives where sophisticated new tracking and analytical tools are being used to understand the complex trade-and-impact relationships at play by following commodities like soy from field to factory and supermarket shelf, or by using big data to help reveal the true extent to which fish are being taken from our oceans.

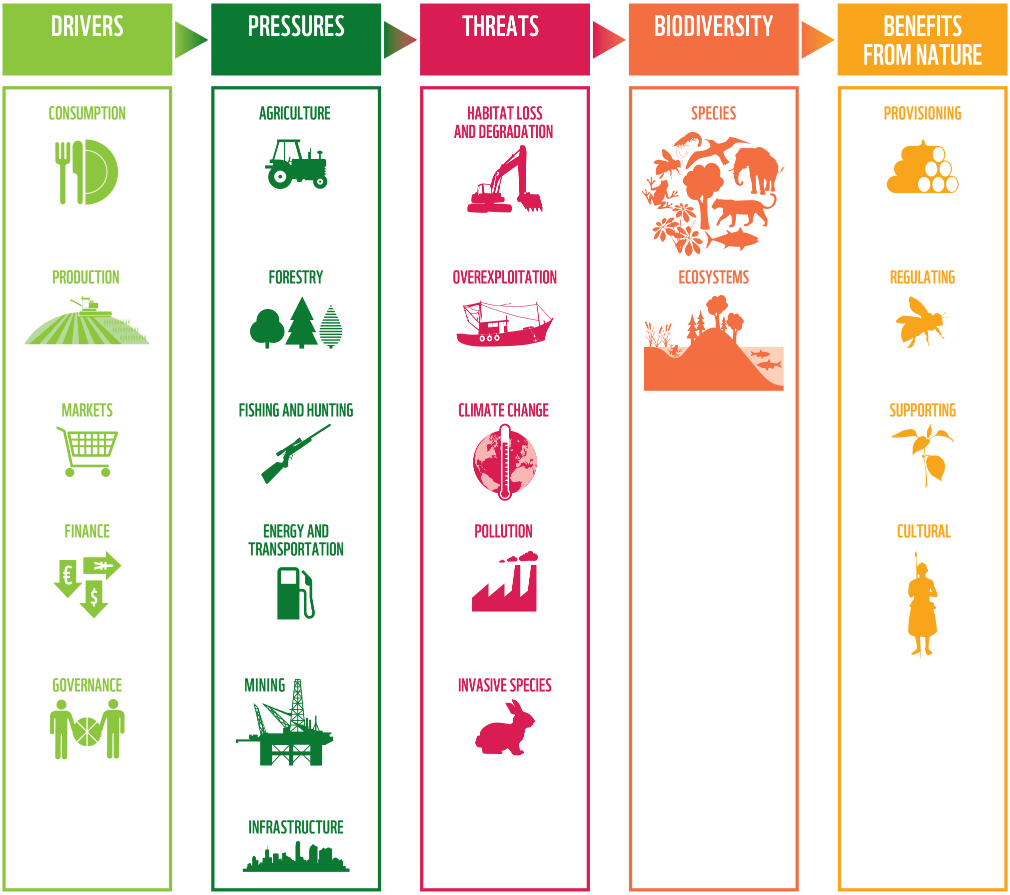


Figure 4: Threats to nature and the drivers and pressures behind them
Habitat loss due to agriculture and overexploitation remain the biggest threats to biodiversity and ecosystems.

"GUNS, NETS AND BULLDOZERS: THE THREATS OF OLD ARE STILL THE DOMINANT DRIVERS OF CURRENT SPECIES LOSS." (MAXWELL ET AL., 2016)[1]

Humanity's demands have far exceeded what Earth can renew. Prior to the explosive population growth of the 20th century, humanity's consumption was much smaller than the Earth's regeneration, but this is no longer the case. Consumption indicators – such as the Ecological Footprint – provide a picture of overall resource use.

RUNAWAY CONSUMPTION

Laurel Hanscom,
Alessandro Galli and
Mathis Wackernagel,
Global Footprint Network

The ability of ecosystems to renew themselves is called biocapacity. The biologically productive areas of Earth provide this service [4,5]. Both the demand on this area – people's Ecological Footprint – as well as biocapacity are measured in global hectares (gha), biologically productive hectares with world-average productivity [6-8]. Together biocapacity and Ecological Footprint provide an empirical basis for determining whether humanity is living within the means of our planet, and how this relationship has been altered over time [9]. Through changes in technology and land management practices, biocapacity has increased about 27% in the past 50 years. But it has not kept pace with human consumption: humanity's Ecological Footprint has increased about 190% over the same time period.

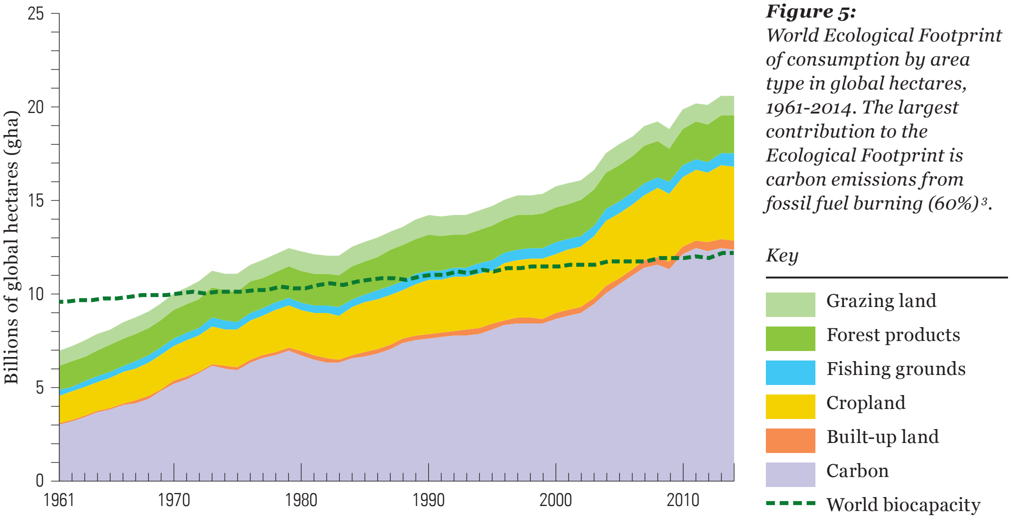


Figure 5:
World Ecological Footprint of consumption by area type in global hectares, 1961-2014. The largest contribution to the Ecological Footprint is carbon emissions from fossil fuel burning (60%) [3].

The Ecological Footprint of consumption

Follow any supply chain to see that natural resources power our interconnected economic and social systems. In turn, our economic and social systems enable human achievement and wellbeing. Indeed, the welfare of modern human society is highly dependent on the systems we have established for distributing and redistributing resources.

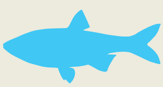
Prior to the explosive population growth of the 20th century, humanity's rate of consumption was much smaller than the Earth's rate of renewal. As a result, prevailing economic models are based on growth, very rarely taking resource limitations into account. But this simplification is no longer viable.

Ecological Footprint accounting tracks human demand on nature by quantifying the biologically productive area required to meet all these competing demands, including food, fibre, timber, accommodation of roads and buildings, and sequestration of carbon dioxide from fossil fuel burning. The demand covers six area types [10]:

Figure 6: Land use categories comprising the Ecological Footprint
The Ecological Footprint measures how much demand human consumption places on the biosphere. It is measured in standard units called global hectares [3].

Grazing land footprint measures the demand for grazing land to raise livestock for meat, dairy, leather and wool products.

Forest product footprint measures the demand for forests to provide fuel wood, pulp and timber products.



Fishing grounds footprint measures the demand for marine and inland water ecosystems needed to restock the harvested seafood and support aquaculture.

Cropland footprint measures the demand for land for food and fibre, feed for livestock, oil crops and rubber.

Built-up land footprint measures the demand for biologically productive areas covered by infrastructure, including roads, housing and industrial structures.

Carbon footprint measures carbon emissions from fossil fuel burning and cement production. These emissions are converted into forest areas needed to sequester the emissions not absorbed by oceans. It accounts for forests' varying rates of carbon sequestration depending on the degree of human management, the type and age of forests, emissions from forest wildfires and soil build-up and loss [11].

A SNAPSHOT OF CONSUMPTION WORLDWIDE

Natural resources are unevenly distributed across the Earth. The pattern of human consumption of these resources differs from resource availability, since resources are not consumed at the point of extraction.

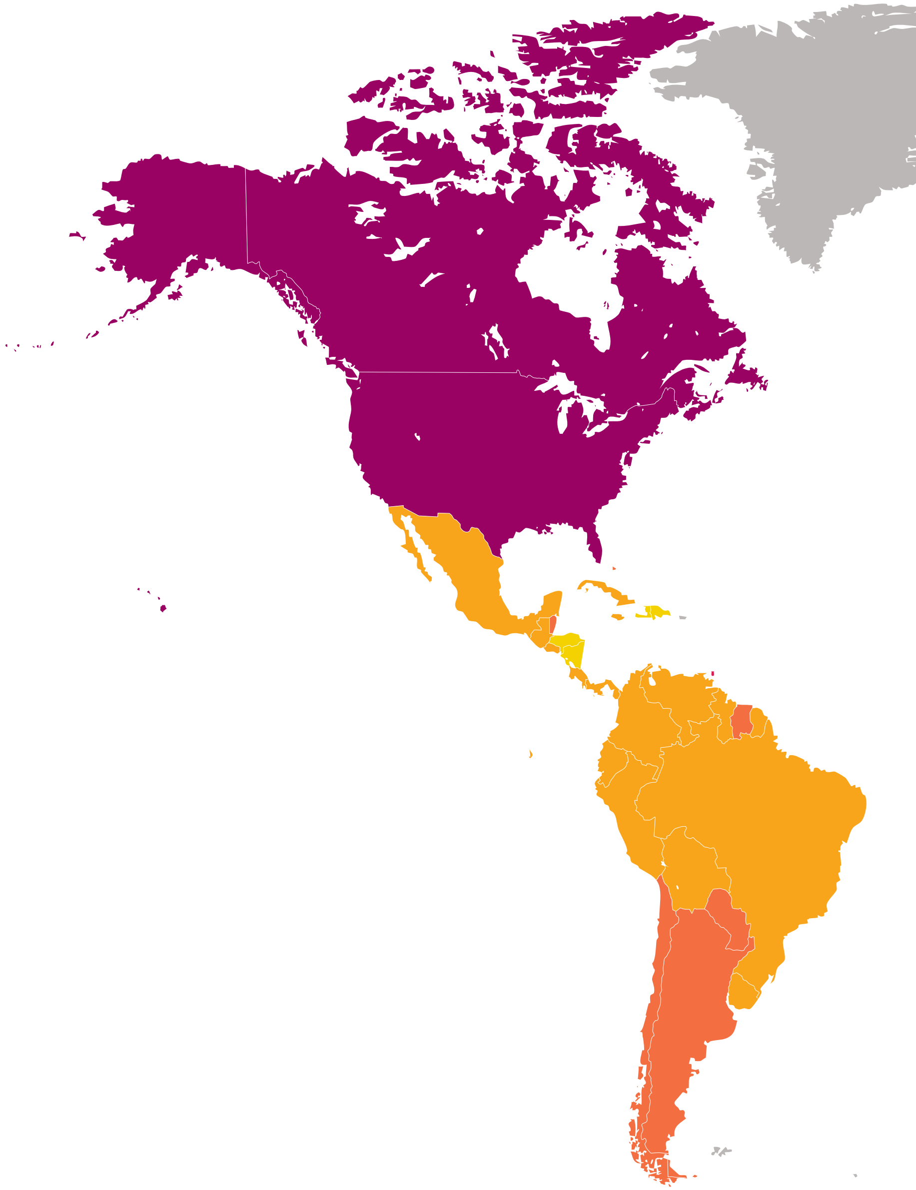
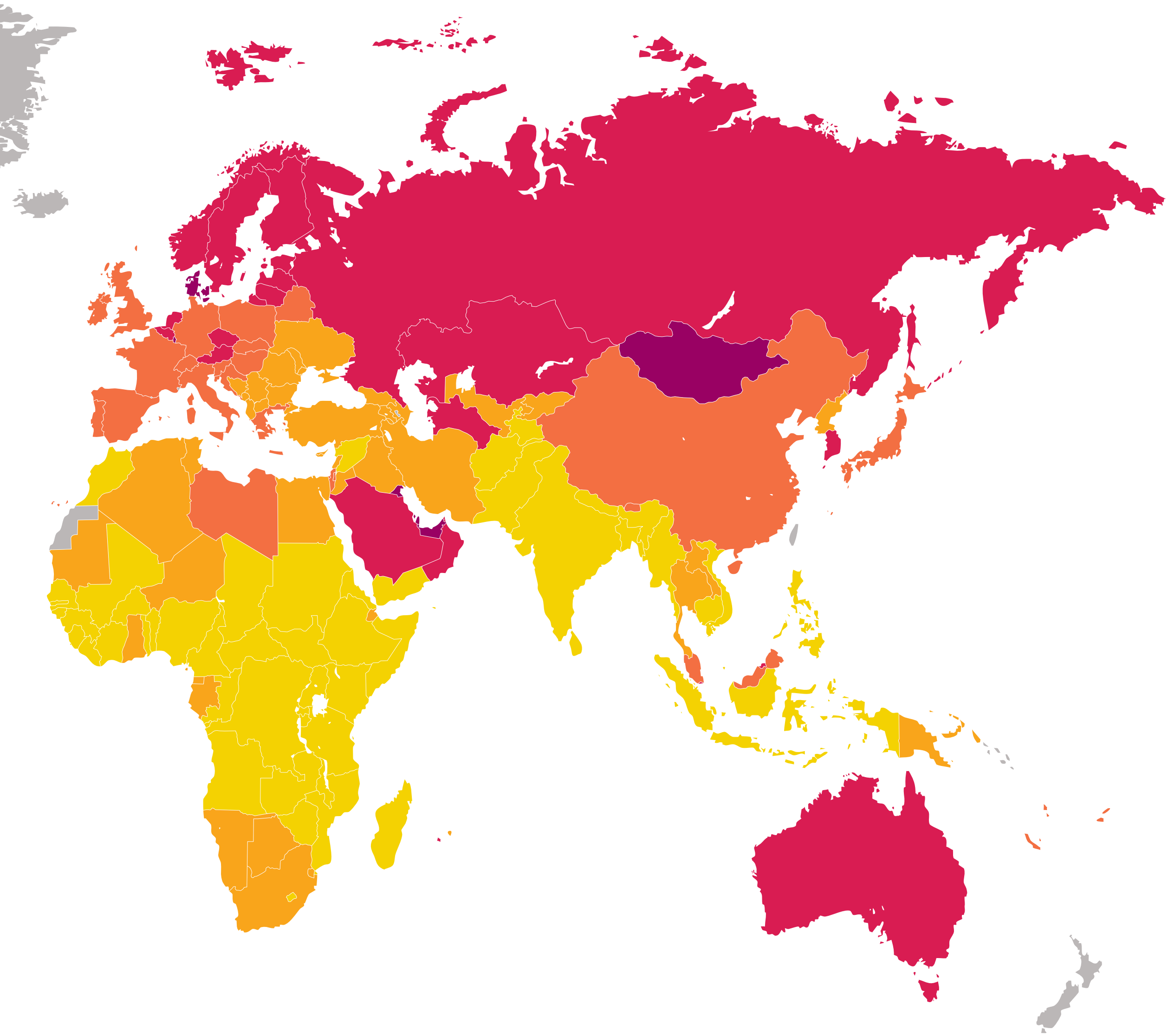


Figure 7: Global map of Ecological Footprint of consumption, 2014
Total Ecological Footprint is a function of both total population and rates of consumption. A country's consumption includes the Ecological Footprint it produces, plus imports from other countries, minus exports[3].

Key

- < 1.75 gha
- 1.75 - 3.5 gha
- 3.5 - 5.25 gha
- 5.25 - 7 gha
- > 7 gha
- Insufficient data

Looking at the Ecological Footprint of each person at the national level provides additional insight into where the world's resources are being consumed [12]. Varying levels of Ecological Footprint are due to different lifestyles and consumption patterns, including the quantity of food, goods and services residents consume, the natural resources they use, and the carbon dioxide emitted to provide these goods and services.



To look deeper into production-related impacts on the environment, the mapping and monitoring of supply chains is crucial to identify and understand how global consumption drives environmental impacts.

INTEGRATING DATA TO CONNECT CONSUMERS TO THEIR IMPACTS

Simon Croft,
Jonathan Green and
Chris West,
Stockholm Environment
Institute

Products are transferred to consumers along supply chains, which frequently involve a series of complex interactions between producers, traders, manufacturers and retailers. Supply chains are the link between the driving forces of environmental change, like consumption activities, and the pressures these impose (such as land-use change), the state of the environment and the resulting impacts (for example, species loss).

SUPPLY CHAINS ARE THE LINK BETWEEN CONSUMPTION AND ITS IMPACTS

Adapting production, supply and consumption activities to create a significantly more sustainable system requires a detailed understanding of how these components link together, the places and actors involved, their respective roles, and the associated environmental impacts.

Consumption 'footprints' attempt to measure the consequences of what we consume on the world around us. Typically, they do so at the scale of pressures rather than states and impacts [13]. Consequently, they often fail to provide detail on how consumption activities act as a driver of on-the-ground impacts, and the complexity of international supply chains makes it difficult to connect the various linked processes that result in changes to the environment. However, understanding these drivers and processes is an important component of designing effective sustainable production and consumption policies.

The data landscape underpinning footprinting methodologies is developing rapidly, providing new opportunities to make important connections between these elements.

Step 1: Assessing impacts on biodiversity

Biodiversity value varies dramatically within and across landscapes. Therefore, the starting point for assessing biodiversity impacts associated with consumption activity is to understand the state of the environment, species' individual habitat preferences, interactions with other species and their geographic ranges.

Advances in remote sensing and vegetation mapping, through initiatives such as the European Commission's Copernicus Satellite Programme, provide unprecedented capabilities to monitor changes in land cover globally, and at high spatial and temporal resolution. For example, the two Sentinel-2 satellites, launched in 2015 and 2017, survey the entire Earth's land surface (bar the poles) every five days at a resolution of between 10m and 60m [14].

This wealth of information needs to be converted into tools to make it easier for companies – and individuals – to visualize, monitor and better understand the consequences of their own actions for the environment. Global Forest Watch is one example of how this data can be used. This online platform provides near real-time information about how forests are changing around the world and includes capabilities for companies to assess impacts associated with the production of the commodities they include in their products [15].

When combined with information on the distribution of biodiversity, this allows assessment of habitat conversion and resulting losses of populations and species. These biodiversity losses can then be linked to the particular commodities produced on converted land. In many areas, fine-scale geographic records on crop production are available. Even when unavailable, ever-more-detailed remote sensing analyses enable the extent and expansion of particular commodity crops to be mapped, showing the direct association between habitat loss and specific production systems [16].

Step 2: Connecting production and consumption

There is a wealth of information that can be used to connect the places where commodities are produced to where they are consumed. For example, UN ComTrade [17] and FAO statistics [18] offer an insight into the global commodity trade. However, some materials are imported into one country, and then processed or simply transferred from one ship to another, and then exported again. Known as the 'Rotterdam Effect' after the busiest port in Europe, this can lead to errors in accurately linking goods to their true origin [19]. Chatham House's Resource Trade platform [20] accounts for this phenomenon, and allows the visualization of the country of origin of traded commodities.

While global trade datasets like these offer a first approximation of global commodity interdependencies, they do not provide the fine-scale connections between producer systems and trade flows that are required to reliably link specific impacts to consumers. The new material flow platform Trase combines data from sources such as customs agencies, shipping contracts and tax offices to reveal these sub-national linkages and the trading companies [21,22]. This is important as restructuring and redesigning supply chains to promote sustainability requires information on those involved in order to leverage changes in sourcing behaviour.

EMBEDDED CONSUMPTION CAN FORM A SIGNIFICANT COMPONENT OF A CONSUMER'S TOTAL FOOTPRINT

Step 3: Linking supply chains to consumer demands

Once commodities disperse into the supply chain, these pathways often become complex and opaque. This is especially true for highly processed deforestation-linked commodities such as soy and oil palm, which are often 'embedded' in other products such as animal feed and processed food. Embedded consumption can form a significant component of a consumer's total footprint. Assessing linkages between the production of a commodity and its direct, indirect and embedded consumption is essential in comprehensively analysing the impacts of changes in consumer demand.

Multi-Regional Input-Output (MRIO) models offer one approach to approximating consumer dependence on direct and embedded materials [23]. MRIO datasets describe spending between sectors and economies, and by final consumers. This information, and the interlinkages and dependencies implicit within it, can be used to estimate global reliance on industrial sectors to satisfy localised final demand [24]. Combining this information with fine-scale and detailed material flow data [25] provides the potential for comprehensive, product- and geographically-specific accounts of consumption-associated biodiversity loss.

The way our supply chains are structured, the materials they use, how these are extracted and manufactured, and the consumption choices we make have a myriad of impacts on the world around us. Using different datasets helps us to map these out and understand the consequences of our choices.

CHOICE AND CHANGE: THE IMPACTS OF CONSUMPTION

Pablo Tittonell,
Natural Resources and Environment Program of INTA, Argentina, University of Groningen and the University of Wageningen

Human activities associated with the production or harvesting of food, fibre and energy from terrestrial ecosystems have enormous impacts on biodiversity. Different types of land use affect the balance between wild and domesticated species, the size and quality of habitats, and the non-living chemical and physical parts of the environment that affect living organisms and the functioning of ecosystems.

Impacts of land use choices on biodiversity may be positive or negative, permanent or transitory, localised or global. Negative impacts can be direct, such as direct biodiversity loss (e.g. through deforestation), the disruption of habitats and of biodiversity-mediated functions (e.g. soil formation), or they can be indirect, through their effect on the broader environment that ultimately affects habitats, functions and species richness and abundance (Figure 8).

Direct biodiversity loss

TODAY, AGRICULTURE ACCOUNTS FOR THE LION'S SHARE OF THE CONVERSION OF FORESTED LAND

Today, agriculture accounts for the lion's share of the conversion of forested land. Decreases in forest area and forest quality both impact the plants and animals living within them. A recent study of more than 19,000 species of birds, amphibians and mammals found that deforestation substantially increased the odds of a species being listed on the IUCN Red List as threatened and exhibiting declining populations[26]. The study also found that the risk of becoming more threatened was disproportionately high in relatively intact landscapes. This implies that even minimal deforestation has had severe consequences for biodiversity.

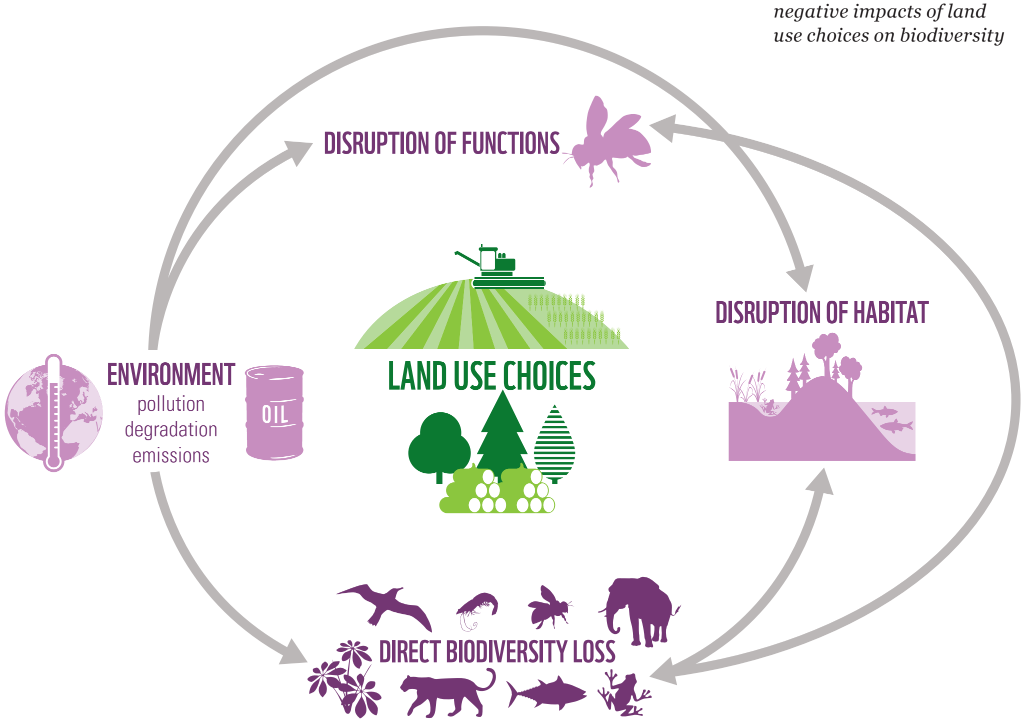
Part of the annual rate of forest loss has been offset in recent years by the expansion of forest onto abandoned agricultural land (2.2 million hectares per year $^{-1}$). Forest plantations (3.1 million hectares per year $^{-1}$) [27] also add to, rather than subtract from, forest cover. Yet these two land use types are quite different from old-growth forests. Plantations especially often represent a considerable simplification in terms of biodiversity: this is explored later in this chapter in the forests section.

Disruption of habitats

The degree of forest fragmentation, for example, is a major threat to biodiversity conservation and ecosystem service provision. Haddad et al. (2015) [28] estimated that in 70% of the forest masses of the world, a forest edge can be found within a mean distance of less than 1km. This has huge implications for habitat structure and quality; forest recolonization and the disruption of corridors for wildlife dispersal; forest microclimate and hydrology; and it influences the ecological dynamics at the interface between forests' open landscapes. Fragmentation can also make forests more accessible to people, increasing the pressure on forest resources such as wood for fuel and timber, bushmeat, and plants for food and medicine. It is also at the interface between forest and open landscapes where forest biodiversity provides ecosystem services of critical importance for food and agriculture, such as pollination or water regulation.

FOREST FRAGMENTATION IS A MAJOR THREAT TO BIODIVERSITY CONSERVATION

Figure 8: *Direct and indirect negative impacts of land use choices on biodiversity*



Pollution and degradation of the environment

Excessive use of synthetic agricultural inputs – including pesticides, antibiotics, hormones and fertilizers – often accompanies agricultural land use. Pesticide use is a well-documented threat to birdlife [29]. It is also associated with declines in soil and aquatic biodiversity [30-33]. The effects of land degradation on people and ecosystems will be further explored in the next section.

Disruption of ecosystem functions

An often-overlooked contribution of biodiversity to human economies and wellbeing is the reduction of risks associated with natural and human-induced disasters [34]. Ecosystems such as forests play an important role in reducing disaster risks, and thus mitigate some of the most acute effects of climate change. When such natural infrastructures are lost, people exposed to natural hazards such as floods, storms and landslides tend to migrate and settle in new areas, often on land that is marginal for land-based livelihood activities, or in cities. This may result in further pressure on nature and biodiversity loss.

Critical reductions in pollinator numbers and performance because of pesticide use [35] can end up reducing agricultural productivity. About 87% of all flowering plant species are pollinated by animals [36], and crops that are partially pollinated by animals account for 35% of global food production [37]. Even when domestic honeybees are used to secure pollination, the presence of wild pollinators improves pollination efficiency [38]. This is further explored later in this chapter.

A less apparent component of biodiversity that is fundamental for food production, but highly susceptible to land-use choices, is the living soil community. A first global assessment of soil biodiversity was published recently in the Global Atlas of Soil Biodiversity [39]. This included the first global map of risks to soil biodiversity and this is explored later in this chapter. Human activities have important consequences for the abundance and/or richness of soil organisms, particularly through the negative impacts of land-use change and agricultural intensification [40]. Soil biodiversity is not only key to sustain food production and other ecosystem services but also to detoxify polluted soils, suppress soil-borne diseases and contribute to the nutritional quality of food [41].

LAND DEGRADATION

Land degradation is a problem in virtually every terrestrial ecosystem, reducing the welfare of more than 3 billion people. A recent assessment found that only a quarter of land on Earth is substantively free of the impacts of human activities and this is projected to decline to just one-tenth by 2050. This ongoing degradation has many impacts on species, the quality of habitats and the functioning of ecosystems. Two recent studies have focused on the dramatic reductions in bee and other pollinator numbers and on the risks to soil biodiversity, critical to sustain food production and other ecosystem services.

Zebu Brahmin cattle in dusty sunset, Pantanal, Brazil.

© Staffan Widstrand - WWF

THE IMPACTS OF LAND DEGRADATION

Robert Scholes,
University of the Witwatersrand and Co-chair of the IPBES Land Degradation and Restoration Assessment

Land degradation is the persistent reduction of the capacity of the land to support both biodiversity and human needs. It takes many forms, including the loss of soil, or soil health, in croplands; loss of habitat and hydrological function in urban areas; deforestation or over-logging in forests; overgrazing and shrub encroachment in rangelands; and drainage and eutrophication in wetlands.

In March 2018, the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) released its latest Land Degradation and Restoration Assessment (LDRA), finding that only a quarter of land on Earth is substantively free of the impacts of human activities [178]. By 2050 this fraction is projected to decline to just a tenth. Wetlands are the most impacted category, having lost 87% of their extent in the modern era. The immediate causes of land degradation are typically local – the inappropriate management of the land resource – but the underlying drivers are often regional or global. The key driver is the growing demand for ecosystem-derived products, beyond the declining capacity of ecosystems to supply them.

ONLY A QUARTER OF LAND ON EARTH IS SUBSTANTIVELY FREE OF THE IMPACTS OF HUMAN ACTIVITIES

The consequences of land degradation are also both local and global. For instance, there is a complex interaction between degradation, poverty, conflict and the migration of people. Degraded land often bleeds sediments and nutrients into rivers, or exports windborne dust to distant locations. Loss of habitat is the key driver of declining terrestrial biodiversity worldwide, and land degradation is a big contributor to global climate change. In the opinion of the LDRA expert authors, most of the UN Sustainable Development Goals cannot be achieved unless land degradation is simultaneously addressed.

Preventing degradation is much cheaper in the long run than permitting it, and then later paying for the impacts and restoration. In many landscapes we no longer have that choice. Yet, there is hope. In all ecosystems assessed, examples of successful damage rehabilitation can be found. Rehabilitating damaged lands is cost-effective despite the high initial price, if the full long-term costs and benefits to society are considered. Many of the necessary actions are at the policy level – locally, nationally and internationally. Coordinated, urgent action is needed to slow and reverse the pervasive undermining of the basis of life on Earth.

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Land degradation is a pervasive, systemic phenomenon: it occurs in all parts of the terrestrial world and can take many forms. Combating land degradation and restoring degraded land is an urgent priority to protect the biodiversity and ecosystem services vital to all life on Earth and to ensure human well-being.

CHILDREN AND NATURE

2. Our shopping basket

An average family on a supermarket outing may not realize how many goods in their shopping baskets – from food to cosmetics – contain palm oil. It is now the world's most produced, consumed and traded vegetable oil. Yet, much of the oil palm's expansion has taken place in high biodiversity tropical forests. The conversion of these, and peat land, to palm oil plantations releases massive quantities of carbon dioxide, fuelling climate change, and destroys the habitat of species like orang-utans. But palm oil doesn't have to be destructive. Consumers, businesses and governments have the power to insist that palm oil is produced sustainably, without causing further loss of forests and biodiversity.

© Richard Stonehouse - WWF

Pollinators: what's all the buzz about?

Michael Garratt, Tom Breeze, Deepa Senapathi, University of Reading

The majority of flowering plants are pollinated by insects and other animals. It has been estimated that the proportion of animal-pollinated wild plant species rises from an average of 78% in temperate-zone communities to 94% in tropical communities [36]. Taxonomically speaking, pollinators are a diverse group, including more than 20,000 species of bees, many other types of insects (e.g. flies, butterflies, moths, wasps and beetles) and even vertebrates such as some birds and bats. Most pollinators are wild but a few species of bees can be managed, such as honeybees (*Apis mellifera, Apis cerana*), some bumblebees and a few solitary bees [42].

Our food production depends heavily upon these pollinators – more than 75% of the leading global food crops benefit from pollination [43]. Some of these crops – especially fruits and vegetables – are key sources of human nutrition. High yields in large-scale intensive production of crops such as apples, almonds and oilseeds depend on insect pollination [44-46] but so do the crops of smallholder farmers in the developing world, where healthy populations of wild pollinators increase yields significantly [47]. Economically, pollination increases the global value of crop production by US$235-577 billion per year to growers alone and keeps prices down for consumers by ensuring stable supplies [48].

Changing land use due to agricultural intensification and urban expansion is one of a number of key drivers of pollinator loss, especially when natural areas, that provide foraging and nesting resources, are degraded or disappear. Improving habitat diversity within the landscape, and the inclusion of non-agricultural habitats within land management plans, have been shown to ameliorate pollinator loss, boost pollinator numbers and improve ecosystem services [49]. Landscape-scale initiatives to improve habitat heterogeneity and connectivity have been incorporated in several national and international initiatives which focus on protecting pollinators [50]. The abundance, diversity and health of pollinators is also threatened by a number of other drivers including a changing climate, invasive species and emerging diseases and pathogens; appropriate local, national and global actions are needed to mitigate these threats as well [42].

The red-tailed bumblebee (*Bombus lapidarius*) is a widespread and generalist species of bumblebee and so it is a really important pollinator of many different crops across Europe.

© Ola Jennersten - WWF-Sweden

WHAT'S SO SPECIAL IN THE SOIL?

Alberto Orgiazzi and
Arwyn Jones,
European Commission Joint
Research Centre (JRC)

A quarter of all the life on Earth can be found beneath our feet [39]. Soil biodiversity encompasses microorganisms (those only visible under microscopes, such as fungi and bacteria), microfauna (with a body size less than 0.1mm, such as nematodes and tardigrades), mesofauna (invertebrates ranging from 0.1 to 2mm in width, including mites and springtails), macrofauna (with a body size from 2 to 20mm in width, including ants, termites and earthworms) and megafauna (that are more than 20mm wide, including soil-living mammals such as moles).

These underground organisms influence the physical structure and chemical composition of soils. They are essential for enabling and regulating critical ecosystem processes such as carbon sequestration, greenhouse gas emissions, and the uptake of nutrients by plants. They represent a storehouse for potential medical applications as well as new biological controls on pathogens and pests.

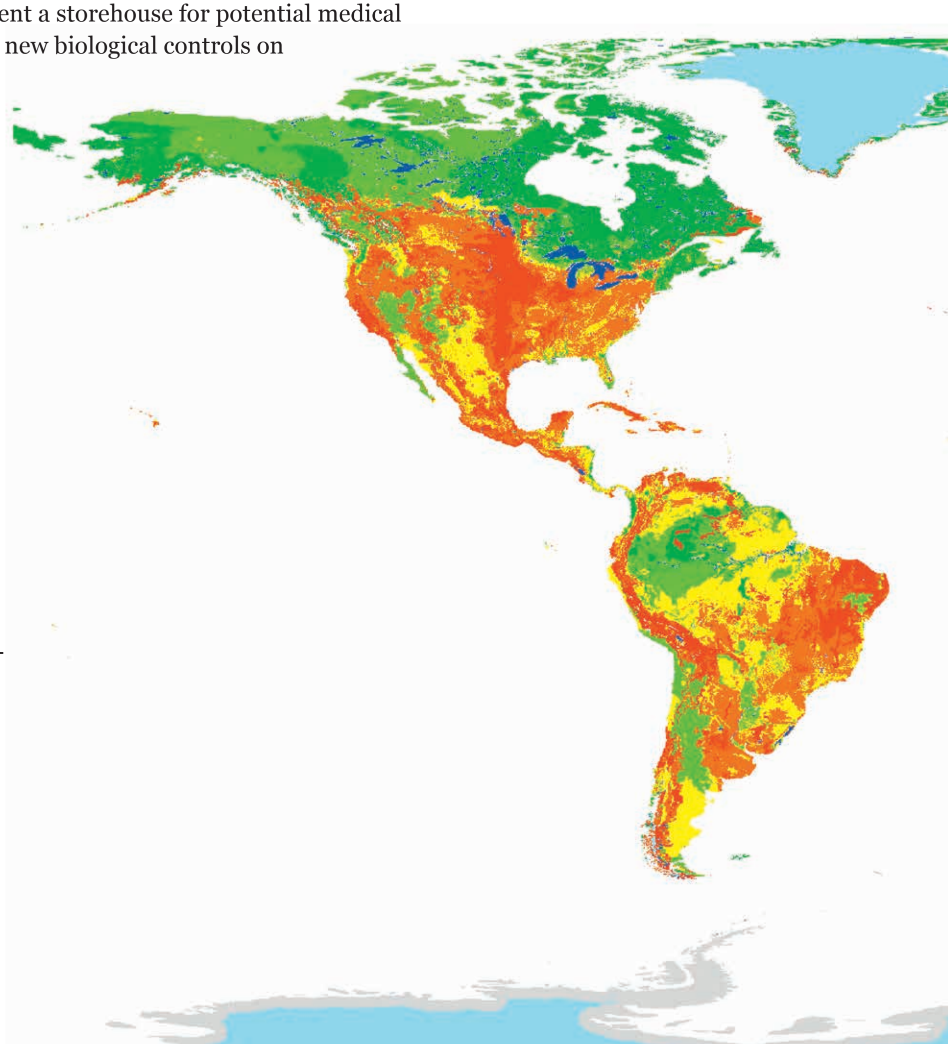


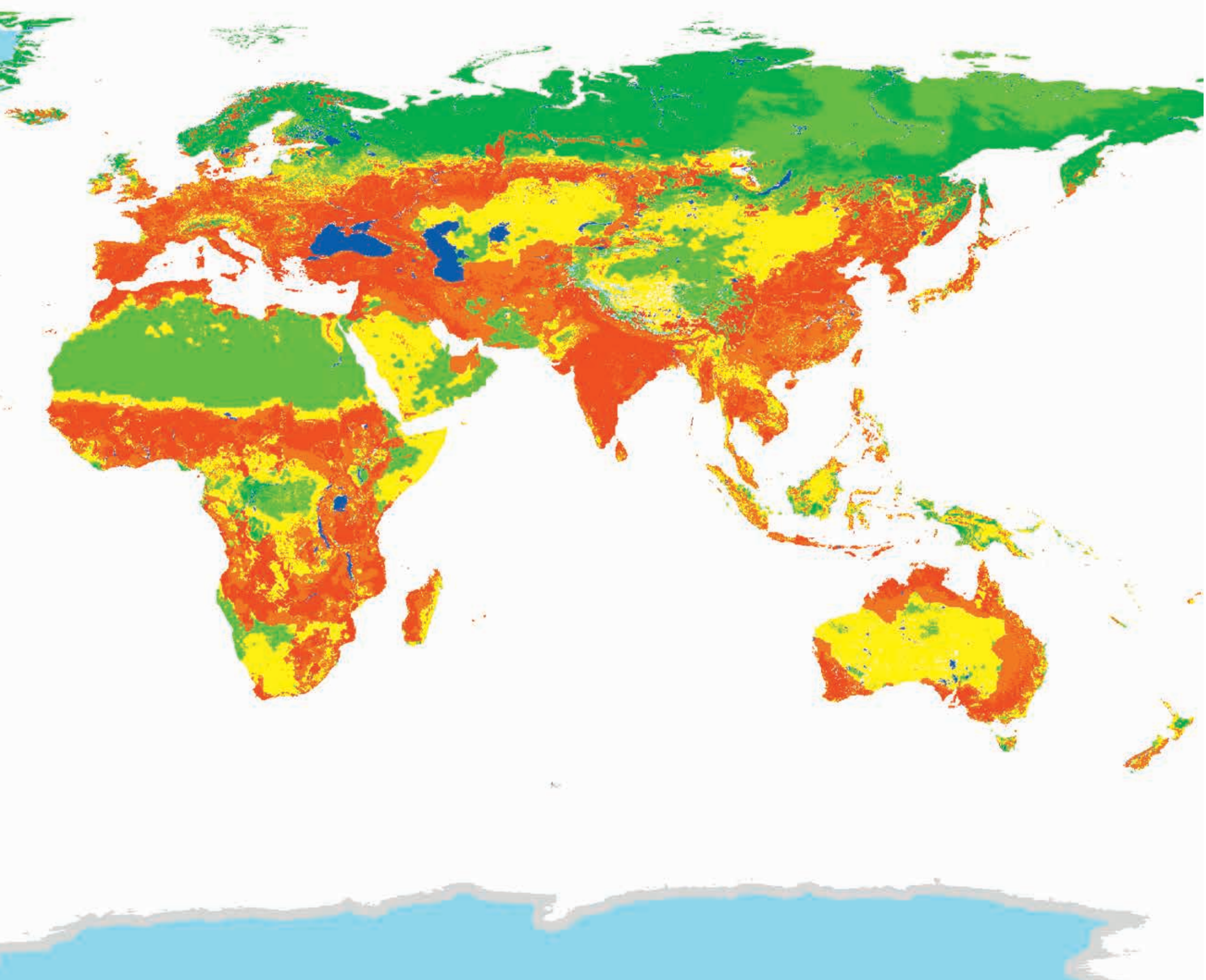
Figure 9: Global map showing the distribution of potential threats to soil biodiversity
All datasets were harmonized on a 0-1 scale and summed, with total scores categorized into five risk classes (from very low to very high) [39].

Key

- Very low
- Low
- Moderate
- High
- Very high
- Not available
- Water
- Ice

The recently published Global Soil Biodiversity Atlas mapped for the first time potential threats to soil biodiversity across the globe [39]. A risk index was generated by combining eight potential stressors to soil organisms: loss of above-ground diversity, pollution and nutrient overloading, overgrazing, intensive agriculture, fire, soil erosion, desertification and climate change. Proxies were chosen to represent the spatial distribution of each threat. Figure 9 shows the distribution of index scores and represents a first attempt to assess the distribution of threats to soil organisms at global scale.

The areas with the lowest level of risk are mainly concentrated in the northern part of the northern hemisphere. These regions are generally less subjected to direct anthropogenic effects (e.g. agriculture) although indirect effects (such as climate change) may become more significant in the future. Not surprisingly, the areas with highest risk are those that reflect the greatest exposure to human activities (e.g. intensive agriculture, increased urbanization, pollution).



Globally the rate of net forest loss has slowed due to reforestation and plantations; but while decreasing over time, deforestation rates are still high in tropical forests, which contain some of the highest levels of biodiversity on Earth. While throughout history people have cleared forest land for food and farming and harvested forest resources to support their livelihoods and market demand, now the pressures on these forests are more industrial and more connected with global market trends.

VALUING FORESTS FOR PEOPLE AND NATURE

Karen Mo, Pablo Pacheco and Huma Khan, WWF

Forests are among the richest ecosystems. Tropical, temperate and boreal forests cover nearly 30% of the Earth's land area [27], and yet they are home to more than 80% of all terrestrial species of animals, plants and insects [51,52].

While globally the rate of forest area net loss has slowed due to reforestation and the establishment of new plantations, as well as policy and regulatory efforts to reduce forest conversion, it has continued at relatively high levels in tropical forests, particularly in some frontier areas in South America, sub-Saharan Africa and Southeast Asia [53]. In one study carried out in 46 countries in the tropics and subtropics, large-scale commercial agriculture and local subsistence agriculture were responsible for about 40% and 33% of forest conversion, between 2000 and 2010 [54]. The remaining 27% of deforestation was due to urban growth, infrastructure expansion and mining (this is further explored in FAO FRA 2016 [27]).

Yet it is not just forest area that is being reduced by human activities; forest quality is also being affected. On a global scale, the area of minimally disturbed forests declined by 92 million hectares between 2000 and 2013, at the rate of 0.6% per year [55]. Using proximity to forest edges as a way of measuring forests' vulnerability shows that 60-70% of the world's forests are at risk from the negative effects of human activities, altered microclimate and invasive species [28,56,57].

What does the future hold? The pressure on forests from both small- and large-scale agriculture is likely to continue in order to growing demand for fibre and fuel as well as for food. Between 1971 and 2016 the global production of major food crops – wheat, rice, maize and soy – increased by 116%, 133%, 238% and 634% respectively [18]. In the future, there will be many more mouths to feed as the current world population of 7.6 billion is expected to reach 8.6 billion in 2030, rising to 9.8 billion in 2050 [58]. While part of the increased food supply will originate from growing yields in existing agricultural lands, additional land will be needed.

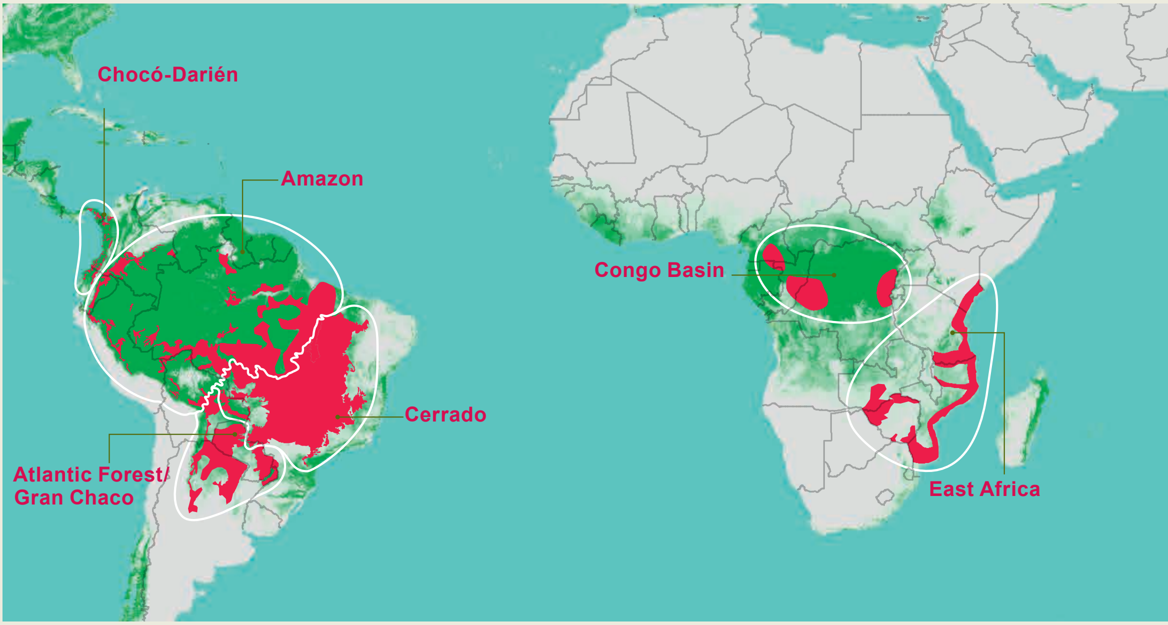
This will further increase the pressure on tropical forests, thus continuing to threaten priority areas for biodiversity conservation, unless there is a fundamental shift in how forests are valued for the many benefits they provide. For example, in addition to providing habitats for animals and livelihoods for people, forests also offer watershed protection, prevent soil erosion and mitigate climate change. WWF explored some of these vulnerable areas as part of the latest chapter of a series of Living Forests reports [59].

Living Forests report series

In the last chapter in a series of five Living Forests reports, WWF highlighted areas of forest most vulnerable to deforestation between 2010 and 2030 [59]. By drawing on projections in the International Institute for Applied Systems Analysis 'Living Forests Model', a major literature survey and interviews with dozens of experts around the world, the report identified 11 deforestation fronts (shown overleaf in figure 10). These are places where the largest concentrations of forest loss or severe degradation are projected to occur between 2010 and 2030 under business-as-usual scenarios and without interventions to prevent losses. The report also reviewed the major drivers of deforestation in each of these areas (table 1).

ON A GLOBAL SCALE, THE AREA OF MINIMALLY DISTURBED FORESTS DECLINED BY 92 MILLION HECTARES BETWEEN 2000 AND 2013

DEFORESTATION FRONTS



The most common pressures causing deforestation and severe forest degradation are large- and small-scale agriculture; unsustainable logging; mining; infrastructure projects; and increased fire incidence and intensity. New roads can have a small direct impact but a large indirect effect through opening up forests to settlers and agriculture. Poor forest management, destructive logging practices and unsustainable fuelwood collection degrade forests and often instigate an increasing spiral of degradation that eventually leads to deforestation ('death by a thousand cuts'). Table 1 gives a summary of these pressures [59].

Table 1: Summary of main pressures on forests in different deforestation fronts

Key

- Primary cause of forest loss and/or severe degradation
- Important secondary cause of forest loss and/or severe degradation
- Less important cause of forest loss and/or severe degradation
- Not a cause of forest loss and/or severe degradation

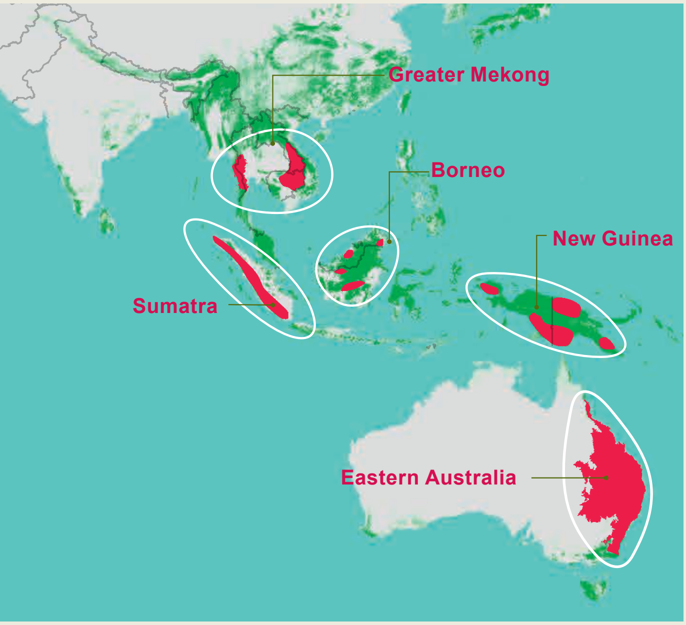


Figure 10:
Hotspots of projected forest loss between 2010 and 2030[59].

Key

Forest

Deforestation fronts and projected deforestation, 2010-2030

	LIVESTOCK	LARGE-SCALE AGRICULTURE	SMALL-SCALE AGRICULTURE & COLONIZATION	UNSUSTAINABLE LOGGING	PULP PLANTATIONS	FIRES	CHARCOAL AND FUELWOOD	MINING	INFRASTRUCTURE	HYDROELECTRIC POWER
AMAZON	red	red	red	yellow		orange		orange	red	red
ATLANTIC FOREST/GRAN CHACO	red	red		orange	orange	orange	orange	orange	red	yellow
BORNEO		red	orange	orange	orange	orange		orange	yellow	orange
CERRADO	red	red					yellow	yellow	orange	yellow
CHOCÓ-DARIÉN	red	red	red	orange				red	red	
CONGO BASIN	yellow	orange	red	orange			red	orange	orange	
EAST AFRICA	red	yellow	red	orange		red	red	orange	orange	
EASTERN AUSTRALIA	red		yellow	orange				yellow		
GREATER MEKONG		red	orange	orange	orange		yellow		yellow	yellow
NEW GUINEA		red	orange	orange	yellow	yellow				
SUMATRA		yellow	red	orange	orange	orange			red	

The rapid loss of some of the ocean's most productive and species-rich habitats like coral reefs, mangroves and seagrasses threatens the wellbeing of hundreds of millions of people. Plastic pollution is also a growing global problem. Plastic debris has been detected in all major marine environments worldwide, from shorelines and surface waters down to the deepest parts of the ocean, even at the bottom of the Mariana Trench. Almost 6 billion tonnes of fish and invertebrates have been taken from the world's oceans since 1950. Now, big data and a new wave of technologies are helping to improve our understanding of what is happening in our oceans by tracking where large vessels are travelling. Layering this information together with data from a range of sources is helping us to build up a more comprehensive picture of our ocean footprint.

OCEAN HABITATS VITAL TO HUMANITY IN STEEP DECLINE

John Tanzer, Paul Gamblin and Linwood Pendleton, WWF

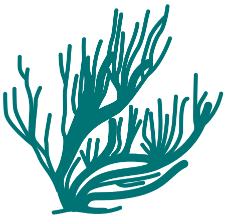
Billions of people worldwide - especially the world's poorest- rely on healthy oceans to provide livelihoods, jobs and food and the range of goods and services that flow from coastal and marine environments. The FAO estimates that fisheries and aquaculture alone assure the livelihoods of 10-12% of the world's population, and 4.3 billion people are reliant on fish (including freshwater) for 15% of their animal protein intake [60]. Nearly 200 million people depend on coral reefs to protect them from storm surges and waves [61].

However, some of the key habitats that underpin ocean health and productivity are in steep decline. Coral reefs support more than a quarter of marine life [62] but the world has already lost about half of its shallow water corals in only 30 years [63]. If current trends continue, up to 90% of the world's coral reefs might be gone by mid-century [64]. The implications of this for the planet and all of humanity are vast.

NEARLY 200 MILLION PEOPLE DEPEND ON CORAL REEFS TO PROTECT THEM FROM STORM SURGES AND WAVES

What is widely recognized as a crisis for biodiversity also risks becoming a major humanitarian challenge, particularly for coastal areas in South East Asia, Melanesia, Coastal East Africa and the Caribbean where there is strong dependence of communities on marine resources for food and livelihoods [65].

Tropical seas overheated by climate change have bleached, damaged and killed coral at unprecedented levels. Mass bleaching was first documented in the 1980s and satellite imagery has connected the distribution of bleaching events on Australia's Great Barrier Reef in 1998, 2002 and 2016 with increased sea surface temperatures [66]. In the aftermath of the bleaching event in 2016, extreme, prolonged heat led to catastrophic die-off of fast-growing coral species – which have complex shapes that provide important habitats – and these were replaced by slower-growing groups that shelter fewer sea creatures. This drastically changed the species composition of 29% of the 3,863 reefs that make up the Great Barrier Reef [67]. Other threats to coral reefs include overfishing, selective fishing and destructive fishing practices, and pollution from runoff which sullies reef waters, compromising coral health [68].



Mangroves are a key natural asset for many tropical and subtropical coastlines, providing livelihoods to many millions of coastal families and protecting them from violent storms and coastal erosion [69,70]. They sequester nearly five times more carbon than tropical forests [71] and provide nurseries to innumerable juvenile fish species that grow to join wider ocean ecosystems. Clearing for development as well as over-exploitation and aquaculture have contributed to a decline in the extent of mangroves by 30% to 50% over the past 50 years [71].

IF CURRENT TRENDS CONTINUE, UP TO 90% OF THE WORLD'S CORAL REEFS MIGHT BE GONE BY MID-CENTURY

Seagrasses, marine flowering plants that include the widely distributed genera *Zostera, Thalassia*, and *Posidonia*, also represent important coastal ecosystems that provide critical human benefits including habitat that supports commercial and subsistence fisheries, nutrient cycling, sediment stabilization, and globally significant sequestration of carbon (reviewed in Waycott, 2009 [72]). They are threatened directly by destructive fishing practices, boat propellers, coastal engineering, cyclones, tsunamis and climate change, and indirectly by changes in water quality due to land run-off (reviewed in [72]). In their global assessment, Waycott et al. 2009 [72] found that seagrasses have been disappearing at a rate of 110 km^2 per year since 1980 and that 29% of the known areal extent has disappeared since seagrass areas were initially recorded in 1879. These rates of decline are comparable to those reported for mangroves, coral reefs and tropical rainforests, and place seagrass meadows among the most threatened ecosystems on Earth.

Global Fishing Watch is harnessing vessel tracking systems, satellite data, artificial intelligence and Google's computing power to generate a clearer view of global industrial fishing activity by larger vessels, weighing 300 tonnes or more.

TRACKING THE GLOBAL FOOTPRINT OF FISHERIES

Sarah Bladen and
David Kroodsma,
Global Fishing Watch

Millions of square kilometres of ocean and hundreds of thousands of fishing vessels – the fishing industry has long been hard to monitor, and its global footprint is difficult even to visualize. A lot of industrial fishing takes place unobserved, far from land; once the boats move on, they leave behind few visible traces of their activity. In this environment, illegal fishing activity flourishes and is thought to be worth between US$10 billion and US$23 billion per year [73]. Now, a wave of new technologies is creating an information revolution that has the power to transform our understanding of what's happening on our blue planet.

NEW TECHNOLOGIES ARE CREATING AN INFORMATION REVOLUTION TO TRANSFORM OUR UNDERSTANDING OF ILLEGAL FISHING

Global Fishing Watch is an international non-profit organization committed to advancing the sustainability of our oceans through increased transparency. It processes data from Automatic Identification System (AIS) transponders used by large vessels to publicly broadcast their position in order to avoid collisions at sea. Vessels using AIS continuously send out signals showing their identity, position, course and speed, and this information is picked up by satellites. According to the International Convention for the Safety of Life at Sea, while on international voyages, large fishing vessels (over 300 tonnes), cargo ships over a certain weight, and all passenger ships are required to use AIS.

By analysing the identity, speed and direction of broadcasting vessels, we can derive new intelligence on vessel behaviour and activity. Global Fishing Watch uses machine learning algorithms to determine which vessels are fishing boats, and where, when and how they are fishing. Global Fishing Watch has so far analysed 22 billion messages publicly broadcast from vessels' AIS positions between 2012 and 2016.

Figure 11: Global Fishing Activity, 2016
Industrial-scale fishing activity by vessels broadcasting AIS. Fishing hotspots were seen in the North East Atlantic and Mediterranean, Northwest Pacific, and in upwelling regions of South America and West Africa. Boundaries or 'holes' in effort show where regulations apply, e.g. the exclusive economic zones of island states[74]. All the data is available for download[75].

Key

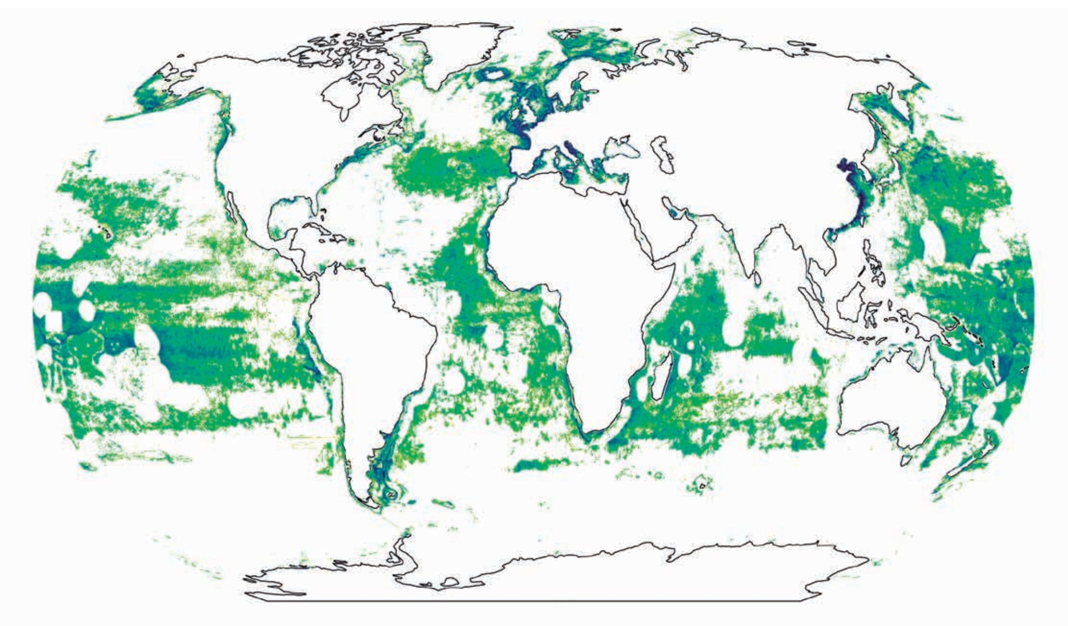
Hours of fishing per km²

- 0.001
- 0.01
- 0.1
- 1
- 10

This data is made publicly available through an online platform, where it can be used by researchers and others. They recorded data on more than 40 million hours of fishing in 2016 alone, tracking vessels over more than 460 million kilometres – a distance equivalent to the moon and back 600 times. The researchers found that when dividing the ocean into a grid of about 50 kilometres on a side (about 160,000 cells), fishing activity was observed in over half the ocean. This represents a huge area, over 200 million square kilometres. Moreover, in almost another 20% of the ocean, few vessels carry AIS or AIS reception is poor, meaning that the actual area of the ocean affected by industrial fishing is likely higher.

For a paper published in *Science*, the Global Fishing Watch research team produced 'heat maps' – see figure 11 – that illustrate where industrial fishing by large vessels is most intense[74]. These 'hot spots' include the northeast Atlantic and northwest Pacific, as well as in nutrient-rich regions off South America and West Africa. The team examined the origin of the fishing vessels as well, finding that just five countries and territories – including China, Spain and Japan – account for more than 85% of the fishing effort they observed on the high seas.

These groundbreaking new datasets, and the high-definition view they give of global industrial fishing activity, are increasingly being used by governments and management bodies to inform policy decisions and enforcement, and to strengthen transparent governance of marine resources in support of sustainability goals.



BUILDING UP A PICTURE

The analysis presented by Global Fishing Watch is just one of many attempts to estimate the global impact of fishing. Although the data set used to generate this map includes only a small proportion of the world's estimated 2.8 million motorized fishing vessels, it contains 50 to 75% of active vessels larger than 24m and >75% of vessels larger than 36m, the size at which most vessels are mandated by the International Maritime Organization to transmit AIS signals [74]. Nevertheless, it does not map small-scale or illegal fishers and many industrial commercial vessels are smaller than this, so it's clear that this is only part of the story.

The data can also be assessed and interpreted in different ways, as is evidenced by a follow-up response to the *Science* paper discussed here by Amoroso et al. 2018 who use a smaller grid size to show that the area of ocean physically swept by fishing gear is substantially smaller [74,164]. As we've explored in other sections of this report, this is where the power of big and open data can help drive conservation science forward. The Global Fishing Watch website brings together the information shown here with data from a range of other sources, including satellite surveys of fishing vessels operating at night and data from within coastal EEZs and fisheries authorities within specific countries, such as the Indonesian Government's Ministry of Maritime Affairs and Fisheries [75]. The website is also interactive, showing changes over time. Other sources document the extent of illegal, small-scale and unreported catches. This includes the Sea Around Us datasets we explore in the next section [76] and other online databases [77]. Layering together datasets like this is helping to build up a more comprehensive picture of what we're catching and where, giving us the true scale of our footprint on the oceans.

Our understanding of the ecological footprint of fishing is likely to evolve, as will the uses we find for these data. By making this high-resolution data publicly available, Global Fishing Watch and others have helped to ensure that this evolution happens transparently and at a rate previously unheard of in marine conservation science.

Artisanal fishermen return to the port after fishing for hake off the coast of Valparaiso, Chile.

© Meridith Kohut - WWF-US

Global sea catch increased from the 1950s on, peaking at 130 million tonnes in 1996. While since then it has decreased at an average rate of 1.2 million tonnes per year, we still extract over 110 million tonnes from the oceans each year.

WHAT AND HOW MUCH HAVE WE CAUGHT?

Maria L.D. Palomares
and Daniel Pauly,
Sea Around Us, University
of British Columbia

Almost 6 billion tonnes of fish and invertebrates (e.g. crustaceans and molluscs) have been extracted from the world's oceans since 1950. Annual catch increased dramatically from 28 million tonnes in 1950 to more than 110 million tonnes in 2014. However, since peaking in 1996 at about 130 million tonnes, catch has been decreasing at an average rate of 1.2 million tonnes per year [78].

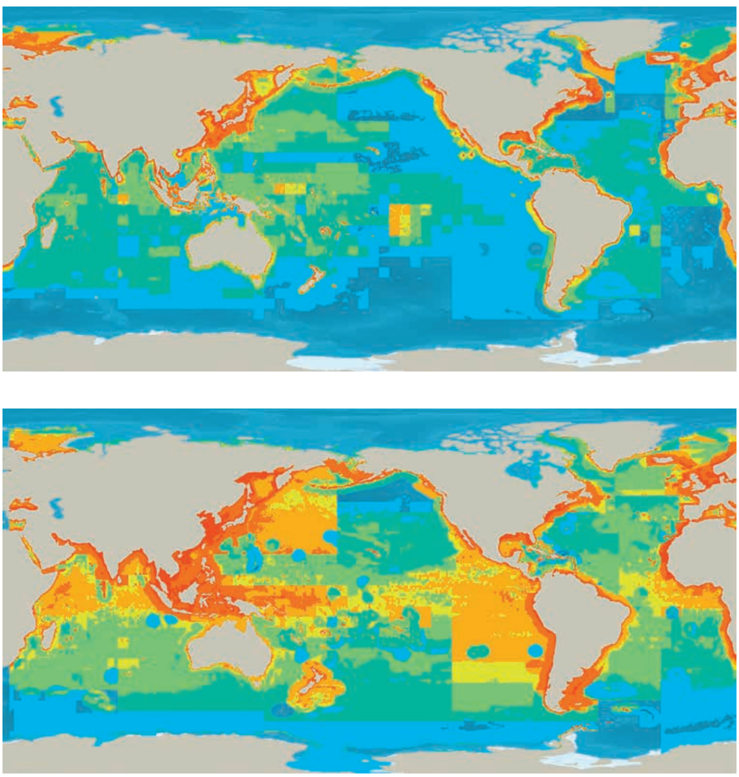


Figure 12: Average annual catches of the world's maritime fishing countries in the 1950s compared to the 2000s
Blue indicates zero or very minute catches, and yellow indicates light or no fishing. Zones of moderately heavy (in orange) to heavy fishing intensity (in red) now wrap around every continent, affecting all coastal areas and many parts of the high seas. Maps generated by the Sea Around Us information system [76].

These figures are the results of research conducted by Sea Around Us, a research initiative at the University of British Columbia that assesses the impact of the world's fisheries on marine ecosystems. Sea Around Us 'reconstructed' post-1950 data from the 273 Exclusive Economic Zones (EEZs) of 217 maritime countries and territories around the world to arrive at a more accurate estimate of actual catch figures than has been officially reported. Each country's EEZ extends 200 nautical miles from its coastline. The researchers combine national-level FAO data from within the EEZs with additional data sources including local catch statistics, social science reports, colonial archives, and expert knowledge [78].

Estimates of unreported catches include the dead fish and invertebrates that are returned to the sea before landing, referred to as discards. Although these have only a low commercial value, they definitely have high ecological impact [79]. Measures of uncertainty in catch statistics are also calculated and incorporated in the final figures. These additions increase the overall estimate of fisheries catches substantially with discards making up 10-20% of reconstructed catches to the year 2000 and less than 10% from then on [79].

Since 2000, 73% of the global catch has come from fishing vessels within their EEZs, while distant-water fleets caught the remainder (either legally or illegally) in the EEZs of developing countries, or on the high seas [80]. About 77% of the cumulative catch since 2000 was taken by industrial fleets, mostly by the top 10 fishing countries – China followed by Peru, Thailand, the Russian Federation, the USA, Indonesia, Japan, Chile, India and Vietnam. The amount of fish caught by these fleets ranges from 114,000 to 774,000 tonnes per year. In contrast, about 20% is taken by artisanal fleets, about 3% by subsistence fishers, and less than 1% by recreational fishers [78].

OUT OF 1,500 SPECIES RECORDED AS BEING CAUGHT, JUST 10 MAKE UP A THIRD OF TODAY'S GLOBAL CATCH

A new analysis of Sea Around Us data for the *Living Planet Report* compares cumulative catches in the 1950s to the 2000's (figure 12). Zones of moderately heavy (in orange) to heavy fishing intensity (in red) now wrap around every continent, affecting all coastal areas and many parts of the high seas. This implies that fishing activities have exposed shallow coastal marine ecosystems to potential long-term damage, notably by trawling [81]. These maps also show the growth of fishing intensity in the south and east, particularly South East Asia, over the last 60 years.

Plastics in the ocean

Carel Drijver and Giuseppe Di Carlo, WWF

Plastic debris in the marine environment is widely documented, but the quantity entering the ocean from waste generated on land is unknown. By linking worldwide data on solid waste, population density and economic status, a recent global study estimated the mass of land-based plastic waste entering the ocean in 2010 to be between 4.8 to 12.7 million tonnes [82].

This estimate is just a snapshot of a single year but plastics, often used just once, are designed to be durable and can potentially remain in the ocean for years before breaking down or sinking (reviewed in Thompson, 2009 [83]). Plastic marine debris ranges from microscopic pieces – either intentionally manufactured for products such as soap, creams, gels and toothpaste or broken down by sunlight, wind and currents – to larger waste items such as bags, cigarette filters, balloons, bottles, caps, or straws which are the most visible form of plastic pollution (reviewed by Law 2017 [84] and for examples in the Mediterranean see UNEP/MAP, 2015 [85]). Plastic debris has been detected in all major marine environments worldwide, from shorelines and surface water [86] down to the deepest parts of the ocean, even at the bottom of the Mariana Trench (reviewed in Law, 2017 [84] and images in the JAMSTEC photo archive [87]).

A 10-year study on the loggerhead turtle showed that 35% of the specimens analysed had ingested debris, which were almost all plastic [90]. In a study carried out in the Mediterranean, 18% of tuna and swordfish had plastic debris in their stomachs [91] as did 17% of blackmouth catsharks in the Balearic Islands, most of which was cellophane and PET [92].

The threat is growing. By using a mixture of literature surveys, oceanographic modeling and ecological models, Wilcox et al. explored the risk of plastic ingestion to 186 seabird species globally [96]. Their models indicate that today, 90% of the world's seabirds have fragments of plastic in their stomachs compared to only 5% in 1960. Impacts were found to be greatest at the southern boundary of the Indian, Pacific and Atlantic Oceans, a region thought to be relatively pristine. If action is not taken to reduce the flow of plastics into the sea, their models predict that plastic will be found in the digestive tracts of 99% of all seabird species by 2050.

Green sea turtle (*Chelonia mydas*) with a plastic bag, Moore Reef, Great Barrier Reef, Australia. The bag was removed by the photographer before the turtle had a chance to eat it.

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THREATS AND PRESSURES ON OUR SOURCE OF LIFE

Freshwater ecosystems provide habitat for more than 100,000 known species of fishes, molluscs, reptiles, insects, plants and mammals despite covering less than 1% of the Earth's surface. In addition, freshwater habitats such as lakes, rivers and wetlands are the source of life for all humans and command high economic value. They are also the most threatened, strongly affected by factors such as habitat modification, fragmentation and destruction; invasive species; overfishing; pollution; forestry practices; disease; and climate change. In many cases, these combined threats have led to catastrophic declines in freshwater biodiversity. New imaging technology is allowing us to view these changes in real time.

Ngonye falls. Sioma Ngwezi. Upper Zambezi. Western Zambia

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THE IMPORTANCE OF HEALTHY FRESHWATER ECOSYSTEMS

Michele Thieme,
Jeff Opperman and
David Tickner,
WWF

Freshwater ecosystems contain disproportionately more species per unit area than marine and terrestrial ecosystems. Although they cover less than 1% of the Earth's surface, freshwater habitats are home to more than 10% of known animals and about one-third of all known vertebrate species[97]. These distinct ecosystems are under increasing levels of threat and, as this report will explore in Chapter 3 using the Freshwater Living Planet Index[98], the trend for freshwater species is alarming[99]. For example, in the 20th century freshwater fishes have had the highest extinction rate worldwide among vertebrates[100].

Freshwater ecosystem health is defined by its water quality and quantity, connectivity to other parts of the system and landscape, habitat condition, and diversity of plant and animal species[101,102]. The pressures created by human settlements and infrastructure, water use, pollution, overexploitation, invasive species and climate change are impinging on all aspects of the health of rivers, lakes, and wetlands[99,103,104].

Globally, wetland extent is estimated to have declined by more than 50% since 1900[105]. Rivers are increasingly disconnected due to dams and other infrastructure, with reservoirs altering natural flow regimes and trapping an estimated > 25% of the total sediment load globally that formerly reached the ocean[106,107].

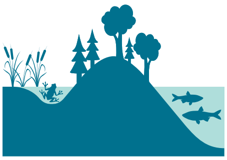
Freshwater ecosystems are also impacted by increasing withdrawal and consumption of surface water for a variety of uses but dominated by agriculture, which is responsible for approximately 70% of total consumption[108-110].

Water quality is also of concern, with eutrophication and toxic pollution being major sources of water quality degradation. Finally, climate change is exacerbating existing stressors and causing changes in the timing, availability and temperature of waters, affecting the condition of freshwater habitats and the life history of freshwater species[111,112].

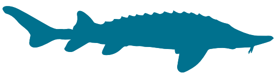
Connected, flowing rivers: critical for freshwater ecosystems and their services

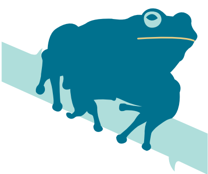
Almost every ancient civilization can trace its origins to a major river: Mesopotamia's Tigris-Euphrates, Egypt's Nile, and China's Yellow and Yangtze rivers among them [113,114].

That's because river systems, including their floodplains and deltas, are among the most biologically diverse and productive ecosystems on the planet. Freshwater and inland fisheries provide the primary source of protein for hundreds of millions of people worldwide. By depositing nutrient-rich silt on floodplains and deltas, rivers have created some of the most fertile agricultural land [115].



For these and other economic and ecosystem benefits to be realized, rivers must retain key characteristics and processes. When natural connectivity and flow are retained the river is called 'free-flowing' (figure 13). However, infrastructure development – especially dams – has caused a dramatic decline in the number of these; currently there are more than 50,000 large dams worldwide [116]. Undammed rivers are still at risk with more than 3,600 hydropower dams planned globally [117].





Options for protecting rivers can entail both preventing the construction of poorly planned dams and ensuring that any dams that are constructed are located and designed to mitigate environmental damage as much as possible. There are plenty of examples where public engagement has influenced dam siting [118,119] and prices for renewable sources, such as wind and solar, are dropping precipitously alongside other advances such as grid integration and improved storage technologies. Collectively, this 'renewable revolution' can catalyse other pathways for energy development, suggesting that countries can meet energy objectives with less hydropower, and therefore fewer dams, than previously planned.

River protection can also occur via various legal and policy mechanisms. Legal protections for rivers began in the United States which became the first country to pass national-level legislation to protect wild rivers with the National Wild and Scenic Rivers Act in 1968 [120]. Recently Mexico created a new model for effectively protecting rivers. The National Water Reserves Program 'reserves' a certain percentage of the river's flow for nature, thus ensuring it will continue to support people and economic activities while maintaining flow and connectivity.

As of June 2018, Mexico had authorized/approved more than 300 water reserves, including one for the country's longest remaining free-flowing river, the Usumacinta River. Each reserve declaration will remain active for the next 50 years [121]. Norway's legal framework offers an excellent example of how planning and policy can direct hydropower toward low-conflict rivers and away from high-conflict rivers. This type of basin-level or system-scale approach can help to avoid costly restoration efforts into the future [122].

As is the case with Mexico's Water Reserves programme, a critical aspect of protecting rivers is maintaining the flow regime necessary to support key river functions and ecosystem services. This flow regime is termed its environmental flow and is defined as "the quantity, timing, and quality of water flows required to sustain freshwater and estuarine ecosystems and the human livelihoods and well-being that depend on these ecosystems" [123]. The science of environmental flow assessment has advanced rapidly over the last two decades and it is possible now to provide recommendations for environmental flows even in data-scarce regions [124]. Moreover, an increasing number of nations have mandated certain levels of environmental flows as a central tenet of water policy [125]. The implementation of environmental flows often requires challenging shifts in infrastructure planning and water allocation. Still, there are an increasing number of known successes in China, Pakistan, South Africa, Australia and the US [126]. These successes seem to have a number of enabling conditions in common, including the existence of progressive legislation and regulation, collaboration and leadership, resources and capacity, and adaptive management [126]. The Brisbane Declaration and Global Action Agenda on Environmental Flows, published in 2018, is a clarion call to governments and stakeholders to build on previous successes through widespread implementation of environmental flows through legislation and regulation, water management programmes and research, linked by partnership arrangements involving diverse stakeholders [123].

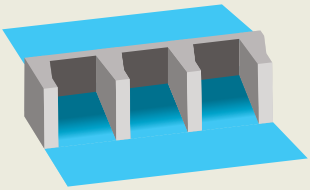
Where river connectivity and flows have already been compromised, actions such as the periodic release of water, floodplain reconnection, or the removal of aging dams can help to restore ecosystem functions. More than 1,500 dams have now been removed from across Europe and the United States. Analyses of river connectivity metrics combined with other ecological, social and economic variables can reveal where the greatest gains in connected rivers and the values that they provide can be achieved for the lowest cost [127-130].

Figure 13:

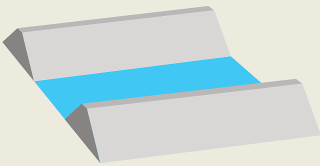
Definition of a free-flowing river

A free-flowing river occurs where natural aquatic ecosystem functions and services are largely unaffected by anthropogenic changes to fluvial connectivity allowing an unobstructed exchange of material, species and energy within the river system and surrounding landscapes beyond.

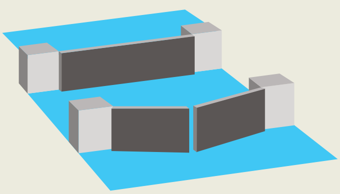
For a river to be 'free-flowing', it must remain highly connected in four ways:



Longitudinally
Which refers to connectivity between upstream and downstream. Dams are the most common disrupter of longitudinal connectivity.



Laterally
Which refers to the ability of a river to swell and shrink, rise and fall naturally, and connect to its floodplains. This is disrupted when roads, buildings and other development (including agriculture when it is protected by levees or dykes) takes place on floodplains, limiting their ability to absorb the river's flow.



Temporally
Or the natural ability of river flows to change intermittently. For example, when a dam is built it consistently holds a volume of water behind it and releases water in a way that does not match the natural timing of the river's natural flows.

Vertically
Which refers to the ability of a river to draw water from or contribute to underground aquifers and the atmosphere. This can be interrupted by over-extraction of groundwater and impermeable development on floodplains, among other causes.

WHAT LIES ON THE SURFACE

Alan Belward,
Jean-Francois Pekel,
Andrew Cottam,
Luca De Felice,
European Commission Joint Research Centre (JRC)

Noel Gorelick,
Google Earth Engine

Where and when water is found on the planet's surface is hugely important as it influences the climate system, the movement of species, sustainable development, and social, institutional and economic security. While surface water is only a tiny fraction of the Earth's water resources, it is the most accessible part, and provides wide-ranging ecosystem services. It is also the easiest form of water to monitor over time over large areas.

Since the mid-1980s, the NASA / United States Geological Survey Landsat programme has collected more than 3 million images of our planet. These have allowed us to build up a picture of changes in the occurrence of water on the Earth's surface over the last three decades. This has been made possible by the development of the Global Surface Water Explorer (Water Explorer), developed by the European Commission's Joint Research Centre and Google's Earth Engine Team [131,132]. Images and data generated by the Water Explorer provide visual information about the location of surface water bodies such as lakes and rivers, and how these have changed over time. The maps and data can be downloaded using an online tool and can be used to support applications such as water resource management, climate modelling, food security and biodiversity conservation.

The Water Explorer shows that over 2.4 million km^2 of the world's lakes and rivers are currently considered permanent – that is, they have remained unchanged over the past three decades. However, in the mid- 1980s there was an additional 90,000km^2 of lakes and rivers – the area of Lake Superior – classified as permanent which have proved to be anything but. Over 70% of the net loss of surface waters is concentrated in just five countries in Central and Western Asia.

Changes to the Rio Grande

The Rio Grande/Rio Bravo basin stretches over 870.000 sq km. of the southwestern United States and northern Mexico [133]. Winding its way through this arid landscape, the Rio Grande – called the Rio Bravo in Mexico – forms a natural boundary between the two countries and creates a thin line of life for millions of people and an incredible range of flora and fauna. Over the last half-century, the condition of the river itself has changed significantly. Dams, water diversion, contamination, invasive species and climate change are changing this once vibrant, productive river[134]. Along parts of the river, the flow has diminished to a trickle, water quality has plummeted, dense stands of invasive giant cane (*Arundo donax*) have taken over banks, and sediment has buried prime aquatic and riparian habitat. As a result, populations of many native and endemic species have become locally extinct and the livelihoods of many riverside communities and citizens compromised.

The Water Explorer provides a new perspective on areas like this where the loss of freshwater is an ongoing crisis and where permanent loss could possibly be averted. Figure 14 shows a 'surface water occurrence' map of the Rio Grande delta, created on the Water Explorer website (the river itself forms the national border between the United States and Mexico). It captures a visual history of the river and the surrounding delta over the last 30 years. The map shows variations in water persistence and location in varying tones. Deep blue signifies water that is present today and was always present. Pale lilac indicates that water was present for only part of the time. The pale pinkish tones depict locations where water was present for a short time in the past. Areas where water never occurred are depicted in white.

If the Rio Grande flowed all year long, every year, the whole area it covers would appear as unbroken deep blue lines in the Water Explorer occurrence map. Now, however, it no longer flows year-round, nor is its flow to the sea in continuous uninterrupted channels. The lack of deep blue tones on the map, the broken line of the river channel, the numerous canals abstracting water (on both sides of the national border) and the dominance of pale lilacs all too eloquently document the change this renowned river is undergoing.

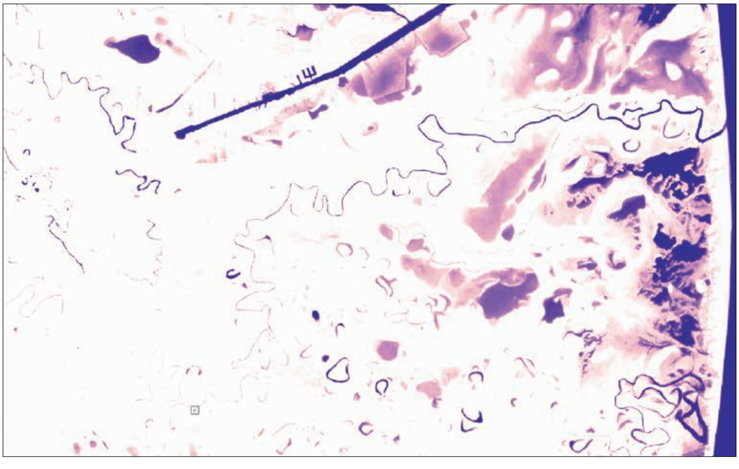


Figure 14: Rio Grande river system
Shades of purple measure the length of time water has been present on the surface (darker tones equate to longer periods of time where water is present). Satellite images Landsat courtesy USGS/NASA. Global Surface Water Explorer maps courtesy JRC/Google https://global-surface-water.appspot.com

Global consumption has exploded since the 1950s and we are now seeing the outcomes of this phenomenon. Worldwide, forests are being lost, freshwater ecosystems are endangered, oceans are overfished and species are disappearing. A global overview is useful but it's also important to understand whether there are differences in threats between different geographic regions and whether similar species are affected by them in different ways. The Living Planet Index is a rich source of this information and can tell us about threats at the species population level.

THREATS THROUGH THE LENS OF THE LIVING PLANET INDEX

Stefanie Deinet,
Louise McRae,
Robin Freeman,
Zoological Society of London (ZSL)

Published now for two decades, the global Living Planet Index has set out the state of the Earth's biodiversity by showing the average rate of change over time across a set of species populations. This is explored in depth in Chapter 3. As such, threats to the planet's natural systems can also be viewed through the lens of the global Living Planet Index, and realm- or species-specific indices.

Information about threats is available for just over a quarter of all species records in the global LPI – 3,789 populations. These threats are grouped under five major categories: habitat degradation and loss, overexploitation, invasive species and disease, pollution, and climate change (based on [135]). Figure 16 (overleaf) outlines each in detail and shows how these threats affect species – either directly or indirectly.

The most commonly reported threat category across all LPI populations is habitat degradation and loss. This accounts for nearly half of all threats within each taxonomic group (45% to 49%) except fish (28%) (see also [136-138]. The second most commonly reported threat is overexploitation. At the lower end, it accounts for 17% of threats to bird populations and – at the high end – 55% of threats to fish populations. Together, habitat loss and degradation plus species overexploitation account for at least two-thirds of all threats recorded for populations within each taxonomic group.

Invasive species and disease are reported most frequently as threats for reptiles and amphibians, and mammals (12% and 9%; see also [137]). Pollution shows up more for birds (10%) and for amphibians and reptiles (5%) than for the other taxonomic groups.

Within the LPI, climate change was most commonly reported as a threat for bird and fish populations – at 12% and 8% respectively and less frequently for other groups [139]. A more in-depth analysis of LPI data also reveals a strong association between the warming climate and declines of bird and mammal populations globally. This shows that population declines have already been greatest in areas that have experienced the most rapid warming [140].

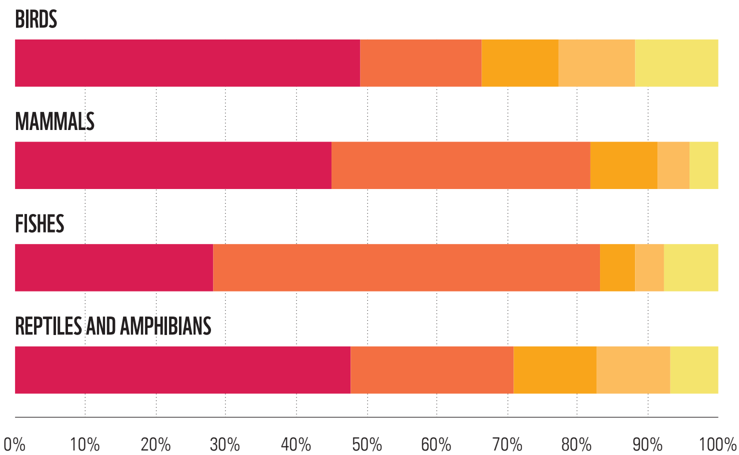
The influence of climate change on wild populations is relatively moderate for now. However, it is quickly accelerating and could take a dominant role in shaping future biodiversity [141-143]. It is also likely that losses of wild species already suffering from more 'traditional' threats like habitat loss and overexploitation may be exacerbated [144] by compromising a species' ability to respond to changes in climate [138].

In the vast majority of cases, species are affected by more than one threat and can experience a cocktail effect as these reinforce each other. Knowledge of which threats are affecting species at different locations and scales is important if we are to successfully bend the species population abundance curve in a positive direction.

Figure 15: Relative frequency of major threats by taxonomic group
Threat data is available for 3,789 populations in the global LPI database. Each of these populations could be associated with up to three different threats. There were 6,053 threats recorded in all [98].

Key

Habitat degradation/loss
Exploitation
Invasive species and disease
Pollution
Climate change



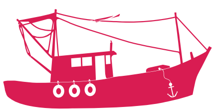
LPI – THREATS TO BIODIVERSITY

Figure 16: Different threat types in the Living Planet Database
Descriptions of the different major threat categories used in the Living Planet Database. This classification is also followed by the IUCN Red List and based on Salafsky et al., 2008 [135].

HABITAT LOSS AND DEGRADATION

This refers to the modification of the environment where a species lives, by complete removal, fragmentation or reduction in quality of key habitat. Common causes are unsustainable agriculture, logging, transportation, residential or commercial development, energy production and mining. For freshwater habitats, fragmentation of rivers and streams and abstraction of water are common threats.

SPECIES OVEREXPLOITATION

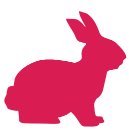


There are both direct and indirect forms of overexploitation. Direct overexploitation refers to unsustainable hunting and poaching or harvesting, whether for subsistence or for trade. Indirect overexploitation occurs when non-target species are killed unintentionally, for example as bycatch in fisheries.

POLLUTION

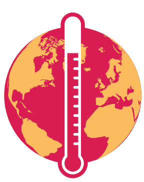
Pollution can directly affect a species by making the environment unsuitable for its survival (this is what happens, for example, in the case of an oil spill). It can also affect a species indirectly, by affecting food availability or reproductive performance, thus reducing population numbers over time.

INVASIVE SPECIES AND DISEASE



Invasive species can compete with native species for space, food and other resources, can turn out to be a predator for native species, or spread diseases that were not previously present in the environment. Humans also transport new diseases from one area of the globe to another.

CLIMATE CHANGE



As temperatures change, some species will need to adapt by shifting their range to track suitable climate. The effects of climate change on species are often indirect. Changes in temperature can confound the signals that trigger seasonal events such as migration and reproduction, causing these events to happen at the wrong time (for example misaligning reproduction and the period of greater food availability in a specific habitat).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Melting iceberg on coast Qaanaaq, Greenland, Arctic.

3. Jaladuddin the storyteller

Jaladuddin is a retired teacher and lives in Kusumtala village on the Sundarban Islands in India. He regularly talks about local history and the impacts of climate change. In many countries children receive no formal education – they may be kept at home to help their families with household chores or the cultivation of land. Informal education is an important way of transmitting knowledge and experience from one generation to the next and many communities have lively storytelling traditions.

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Threats to LPI populations around the world

All freshwater and terrestrial populations in the global LPI are assigned to one of five major biogeographic realms, regions characterized by distinct assemblages of species (defined in Olson et al. 2001[145]). The Index is then recalculated for just the species populations in that region and, where possible, threats for each realm are catalogued. This gives us a better understanding of how biodiversity is changing in different parts of the world and helps us to identify whether different local threat processes are driving these changes.

Information about threats is available for just under a quarter – or 3,789 populations – in the global LPI. Each population can be associated with up to three different threats. Habitat degradation and loss is consistently the most reported threat in all realms; but there is some variation between realms and taxonomic groups.

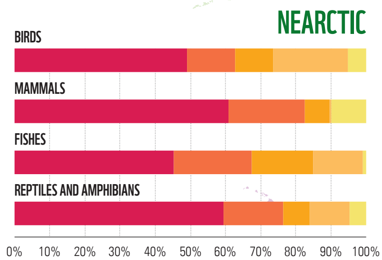
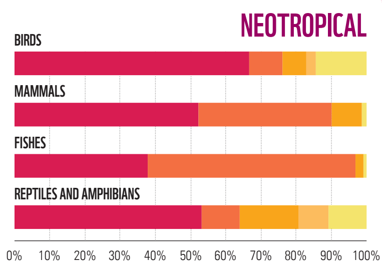


Figure 17: The distribution of threats for each taxonomic group for each realm
Threat data is available for 3,789 – just under a quarter – of the terrestrial and freshwater populations in the global LPI database[91].

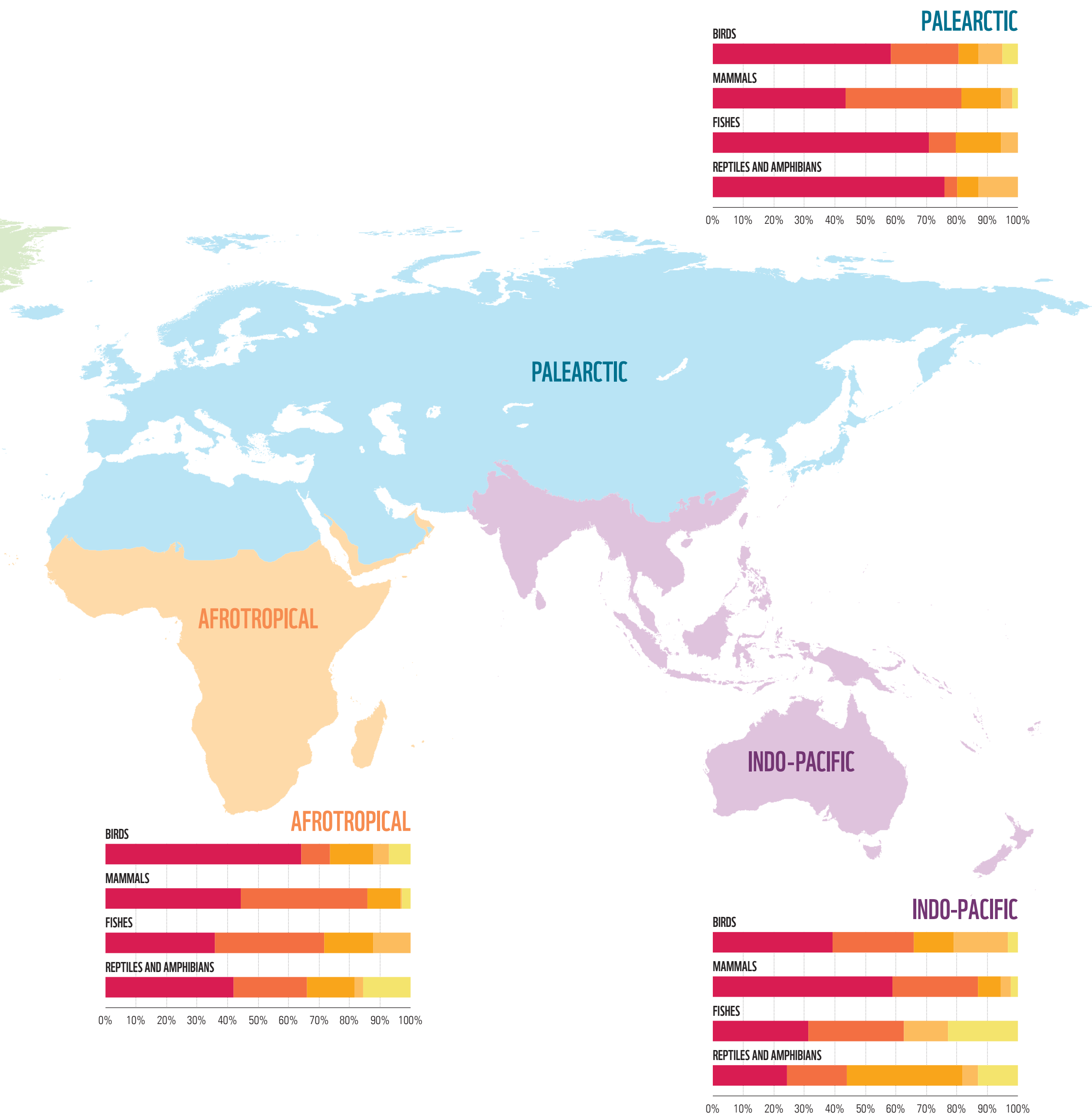
Key

- Habitat degradation/loss
- Exploitation
- Invasive species and disease
- Pollution
- Climate change



What is a biogeographic realm?

Biogeographic realms are regions characterized by distinct assemblages of species. They represent large areas of the Earth's surface separated by major barriers to plant and animal migration – such as oceans, broad deserts and high mountain ranges – where species have evolved in relative isolation over long periods of time.



Penguins on the move: who wins and who loses when the competition heats up?

Harriet Clewlow, British Antarctic Survey (BAS) and University of Exeter
Rod Downie, WWF
Norman Ratcliffe and Phil Trathan, British Antarctic Survey (BAS)
Louise McRae and Stefanie Deinet, Zoological Society of London (ZSL)

Threats to species are often complex and highly interconnected, meaning different species, and even different populations of the same species, can display very different responses. The response can depend greatly upon the nature of the threat, the resilience of the species, their geographic location and the presence/absence of other closely related species[146,147]. Here, we explore ways in which changes in climate are affecting different species of penguins in western Antarctica.

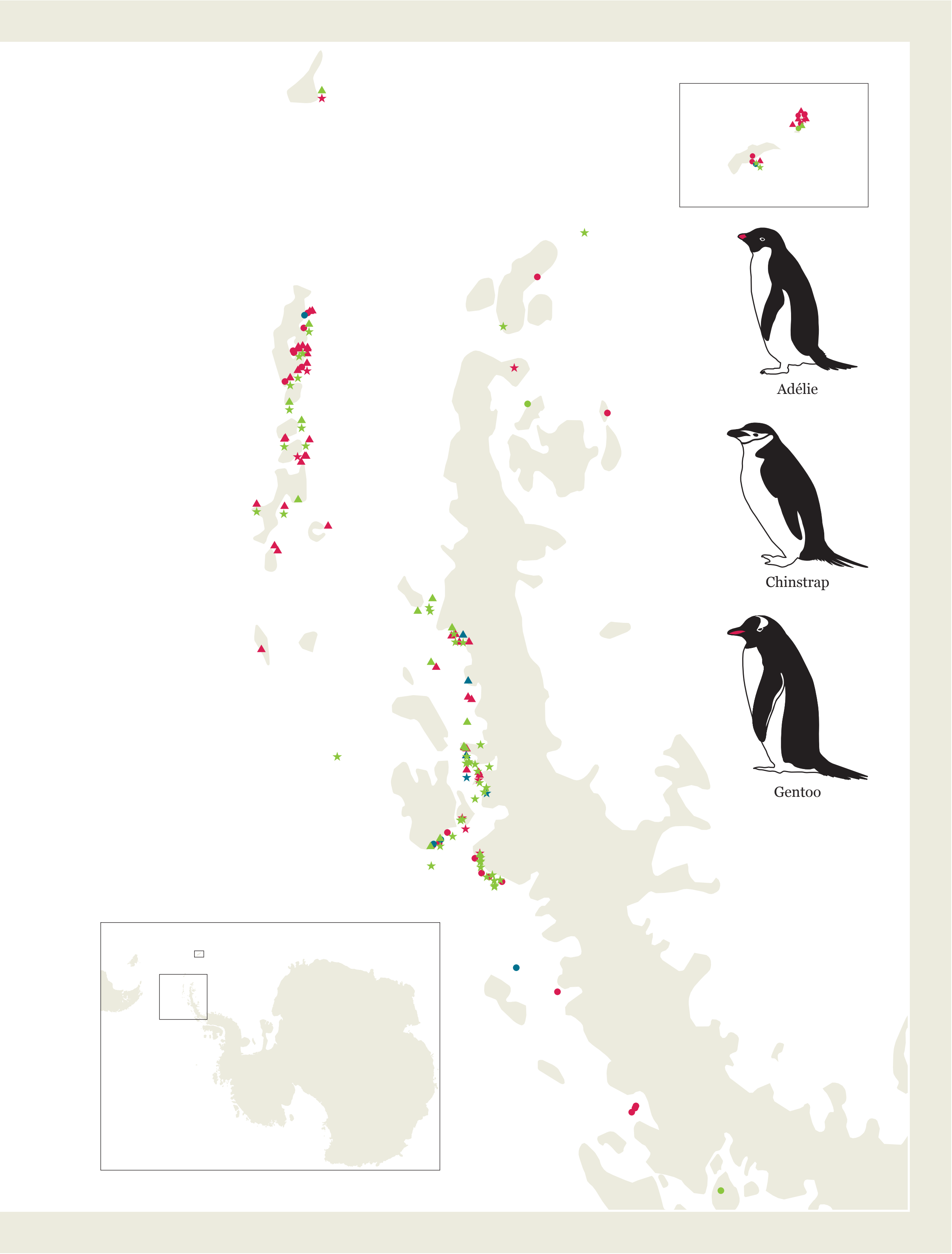
Areas with extreme climates – such as polar regions or deserts – are experiencing dramatic changes in temperatures, as well as severe weather events. The effects of these changes on resident species are often complex and unpredictable. The vast continent of Antarctica offers an excellent example. West Antarctica has experienced rapid increases in temperature (a total +2.8°C rise) during the second half of the 20th century, with recent pauses in this warming in line with natural variability[148,149]. Meanwhile, east Antarctica temperatures have fallen[150]. These shifts in temperature affect habitat and food availability dramatically for different species, including exerting a powerful influence over populations of Antarctica's five penguin species – emperor, Adélie, gentoo, chinstrap and macaroni. Understanding how habitats and species respond to climate change is essential if we are to successfully conserve the biodiversity of these special regions[151].

In west Antarctica, rapid warming is causing sea ice extent to decrease rapidly. As a result populations of the ice-adapted Adélie are generally declining, whereas populations of the ice-averse gentoo penguin are increasing[152,153] (figure 18). Populations of chinstrap penguins are declining around the Scotia Arc but colonies on the South Sandwich Islands are more stable[154]. Meanwhile Adélies are experiencing population increases in east Antarctica, likely associated with the region experiencing temperature declines and increases in sea ice[155].

Figure 18: Location and trend of monitored penguin colonies on the Antarctic Peninsula
The top inset shows the South Orkney Islands (including Signy Island). The points show approximate locations, colours show the average trend for each colony using count data captured between 1970 and 2014, and the shape denotes the penguin species monitored. Data is from MAPPPD[163] with additions from other scientific papers.

Key

- ● Adélie
- ▲ Chinstrap
- ★ Gentoo
- Declined
- Stable
- Increased
- Antarctic Peninsula


Adélie
Chinstrap
Gentoo

Changes in sea ice can only go so far in explaining penguin population trends. On tiny Signy Island in western Antarctica, gentoo penguin numbers have increased by 255% since 1978. At the same time, Adélie and chinstrap penguins have declined by 42% and 68% respectively [152]. These large population shifts seem to be indirectly caused by sea ice declines affecting their food supply [153]. Antarctic krill is the preferred prey of all three penguins [156]. Declines in this food supply do not just directly affect their survival but also affect them indirectly by altering competition between the species for the available krill and for alternative prey, leading to the observed population declines. Gentoos are resident at this breeding archipelago all year round, giving them an advantage over Adélies and chinstraps breeding in the same area: they can respond to environmental conditions and prey abundance to ensure they synchronize their breeding with optimal conditions and take advantage of newly revealed snow-free breeding space [157,158].

Regionally in Antarctica, extreme weather has been linked with calving ice shelves [159,160]. An abundance of regional sea ice close to the coast and large icebergs can block penguins' access to breeding grounds and foraging areas [161], a particular problem in east Antarctica. Extreme sea ice events such as these have already caused an entire Adélie penguin colony to fail to breed twice in four years at Dumont D'Urville in eastern Antarctica [162].

Two Adelie penguins (*Pygoscelis adeliae*) on an iceberg in Antarctica.

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PLANETARY BOUNDARIES

Sarah Cornell,
Stockholm Resilience Centre
and Stockholm University

In recent decades, a clearer scientific picture has emerged of many of the complex links between life, climate, and other aspects of the physical environment on Earth. Field studies, models, Earth observations and geological evidence have all been used to build an understanding of global change, the capacity of living organisms to adapt to change and the systemic risks when adaptation fails.

Our new knowledge has come about none too soon. For now, we can understand today's ongoing destruction of ecosystems and biodiversity in the context of even longer-term and larger-scale changes in the Earth system. We can see that current levels of decline and degradation are not normal – they increasingly resemble some of the catastrophic extinctions in the geological past [165,166], giving us reason to be concerned about planetary health, not just the state of local ecosystems. It is clear that human modifications are causing irreversible changes to the life-sustaining processes and resources that we depend upon.

The Planetary Boundaries concept [167-169] is an effort to use this Earth system perspective to provide information on human-driven changes. The concept suggests that the world's societies need to set limits on human-caused disturbances to tightly linked Earth system processes. It is usually presented as the framework shown in figure 19.

Although the concept is still evolving, it is already a useful integrating framework for illustrating the risks of human interference with the Earth system through our patterns of consumption and production. It presents the idea of a safe zone for critical Earth system processes. Within this so-called safe operating space – which is based on our evolving understanding of the functioning and resilience of the global ecosystem – human societies can develop and thrive.

HUMAN MODIFICATIONS ARE CAUSING IRREVERSIBLE CHANGES TO THE LIFE-SUSTAINING PROCESSES AND RESOURCES THAT WE DEPEND ON

The Planetary Boundaries framework highlights nine critical issues where human activities are reducing the safe operating space: 1) loss of biosphere integrity (the destruction of ecosystems and biodiversity), 2) climate change, 3) ocean acidification, 4) land-system change, 5) unsustainable freshwater use, 6) perturbation of biogeochemical flows (nitrogen and phosphorus inputs to the biosphere), 7) alteration of atmospheric aerosols, and 8) pollution by novel entities, including 9) stratospheric ozone depletion [169].

Current analysis suggests that people have already pushed at least four of these systems beyond the limit of a safe operating space. Attributable global impacts and associated risks to humans are already evident for climate change, biosphere integrity, biogeochemical flows and land-system change [169]. Other assessments indicate that freshwater use has also passed beyond a safe threshold [99,170].

Biosphere integrity plays a critical role in determining the state of the Earth system, regulating its material flows, energy balance, climate, and responses to abrupt and gradual change [182]. Lenton and Williams (2013) describe the biosphere as the totality of all ecosystems on Earth – terrestrial, freshwater and marine – and their living organisms [183]. The biosphere not only interacts with the other planetary boundary categories, but also maintains the overall resilience of the Earth system. Our changing climate will impact the Earth system in many ways because climate influences the ways that ecosystems on land and below water function and interact with each other.

Figure 19: The connections between the Planetary Boundaries
All the Planetary Boundary processes are interlinked as they affect the interactions and feedbacks between biosphere integrity and climate. Some of these effects are stronger and more direct than others. In turn, harm to biosphere integrity and climate change reduces the safe operating space for other processes [169].

Exploring biodiversity and climate in more detail

Biosphere integrity has undergone change throughout human history, but there is no precedent for the current losses of biodiversity and ecosystems. Climate change and ocean acidification are planetary boundary processes that are also in a state of extreme change. Both share a major common cause: carbon dioxide emissions to the atmosphere.

All three of these altered processes are already producing negative impacts on ecosystems and human societies worldwide (e.g. the IPBES 2018 series of Regional Assessments [171-174 and 175-177]). As changes in these three processes continue to accelerate, their interactions mean that effects on organisms and ecosystems extend to all parts of the world, even where there is no direct impact from human activities. The complex interactions make it difficult to predict how the system will respond to future change, and increase the risk of unmanageable ecosystem changes at very large scales.

Ecosystems and societies are also experiencing rising risks from human-induced transformations to other planetary boundary processes. In addition to land-use change explored within this chapter, ecosystems are altered through unsustainable freshwater use and increased flows of nitrogen and phosphorus, especially from fertilizers. These drivers of ecosystem change are often linked with loss of biodiversity on land and in aquatic environments [178].

The Planetary Boundaries framework also highlights the problematic release of chemical pollution, such as the CFCs that threatened to destroy the protective ozone layer high in the atmosphere, and alterations of atmospheric aerosols. These chemical disturbances have multiple effects on ecosystems, so although there is no single global quantification for a planetary boundary, planet-scale processes are increasingly taken into account as the precautionary principle is applied in pollution policy [179-181].

Scientific communities are working to combine their knowledge of these different components of the Earth system in new and better ways. They aim to support better prediction, monitoring and management of ecosystem change in the context of a changing climate and increasingly globalized human drivers.

THERE IS NO PRECEDENT FOR THE CURRENT LOSSES OF BIODIVERSITY AND ECOSYSTEMS AND THIS EXTENDS TO ALL PARTS OF THE WORLD, EVEN WHERE THERE IS NO DIRECT IMPACT FROM HUMAN ACTIVITIES

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Bleached coral caused by loss of algae due to temperature change. Maldives.

CHAPTER 3:
Biodiversity in a changing world

First published 20 years ago, for two decades the Living Planet Index has tracked the state of biodiversity by measuring the population abundance of thousands of vertebrate species around the world. The latest index shows an overall decline of 60% in population sizes between 1970 and 2014. Current rates of species extinction are 100 to 1,000 times higher than the background rate, also known as the standard rate of extinction in Earth's history before human pressure became a prominent factor. Species population declines are especially pronounced in the tropics, with South and Central America suffering the most dramatic decline, an 89% loss compared to 1970. Freshwater species numbers have also declined with a focused Freshwater Index showing an 83% decline since 1970. To put these trends in a broader context, this chapter also explores three other indicators measuring changes in species distribution, extinction risk and community composition. All these results paint the same picture – that of continuing biodiversity loss.

Mountain gorillas (*Gorilla beringei beringei*) and their infant in the Bwindi Impenetrable National Park, Uganda.


© Scott Masciarelli

POPULATION INDICATOR: THE LIVING PLANET INDEX

Stefanie Deinet,
Louise McRae and
Robin Freeman,
Zoological Society London

The Living Planet Index (LPI) is an indicator of the state of global biodiversity and the health of our planet. First published in 1998, for two decades it has tracked the population abundance of thousands of mammals, birds, fish, reptiles and amphibians around the world. It uses the trends that emerge as a measure for changes in biodiversity.

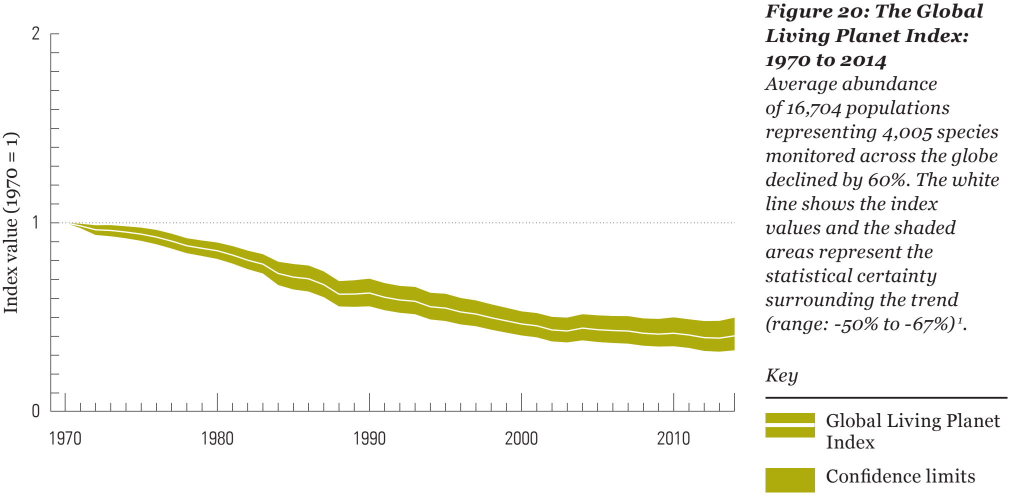


Figure 20: The Global Living Planet Index: 1970 to 2014
Average abundance of 16,704 populations representing 4,005 species monitored across the globe declined by 60%. The white line shows the index values and the shaded areas represent the statistical certainty surrounding the trend (range: -50% to -67%)[1].

The species population data that is collected goes into a global index, as well as indices for more specific biogeographic areas, referred to as realms, based upon distinct groupings of species. This report also includes a Freshwater Living Planet Index to highlight the dramatic decline in freshwater species populations.

This year's indices include data from 1970 – set as a common starting year for many indicators – to 2014, because not enough information is available before 1970 or after 2014 to produce a robust and meaningful index. This is because it takes time to collect, process and publish monitoring data, so there can be a time lag before this can be added to the LPI.

The global index, calculated using available data for all species and regions, shows an overall decline of 60% in the population sizes of vertebrates between 1970 and 2014 (figure 20) – in other words, an average drop of well over half in less than 50 years.

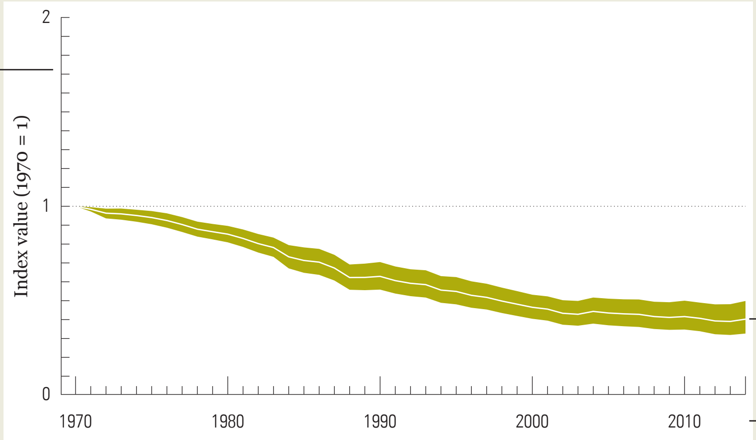
How to interpret the Living Planet Index

Living Planet Indices – whether the Global Index or those for a specific realm or species group – show the average rate of change over time across a set of species populations. These populations are taken from the Living Planet Database, which now contains information on more than 22,000 populations of mammals, birds, fish, reptiles and amphibians. The global LPI is based on just over 16,700 of these populations. This is because some populations overlap in both space and time, so to avoid double-counting, certain populations are not included when calculating a global trend.

Figure 21: Interpreting the LPI
Explanations of the most important terms needed to understand the LPI [1].

Baseline
The index starts at a value of 1. If the LPI and confidence limits move away from this baseline, we can say there has been an increase (above 1) or decline (below 1) compared to 1970.

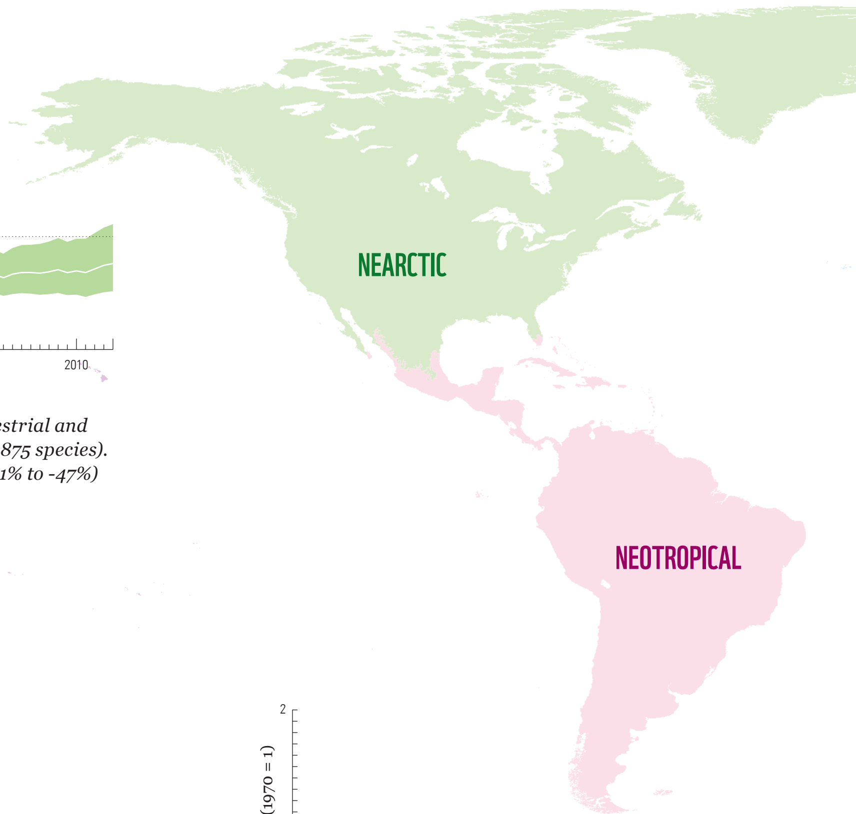
Index values
These values represent the average change in population abundance – based on the relative change and not the absolute change – in population sizes. The shaded areas show 95% confidence limits. These illustrate how certain we are about the trend in any given year relative to 1970. The confidence limits always widen throughout the time-series as the uncertainty from each of the previous years is added to the current year.

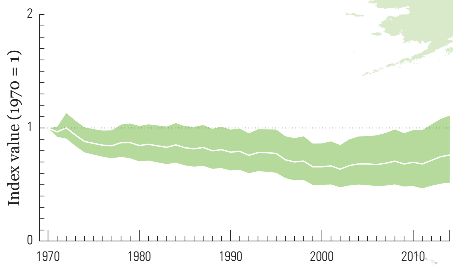


Cut-off
The final year of the index depends on data availability and is the latest year for which we have a good amount of data. For the final year, this is because it takes time to collect, process and publish monitoring data, so there can be a time lag before these can be added to the LPI.

Realm Living Planet Indices

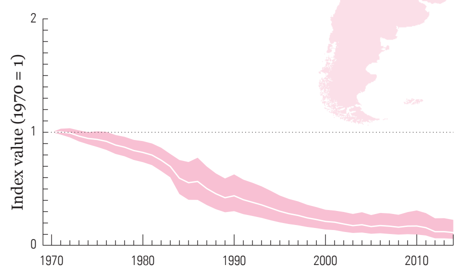
As seen in the map below (figure 22), populations are in decline in all realms, but declines are especially pronounced in the three tropical realms. Here, average vertebrate abundance in 2014 was less than half of what it was in 1970. The LPI indicates that the Neotropical realm, covering South and Central America, and the Caribbean, has suffered the most dramatic decline at 89% loss compared to 1970. Nearctic and Palearctic populations are faring slightly better with declines of 23% and 31%.





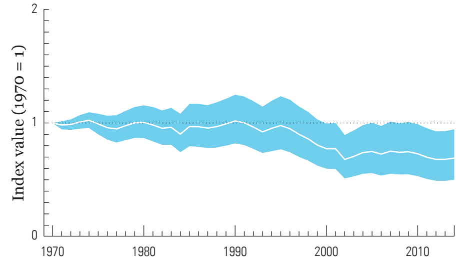
The Nearctic Living Planet Index
The average abundance for 2,417 terrestrial and freshwater populations (representing 875 species). These populations declined by 23% (+11% to -47%) between 1970 and 2014[1].

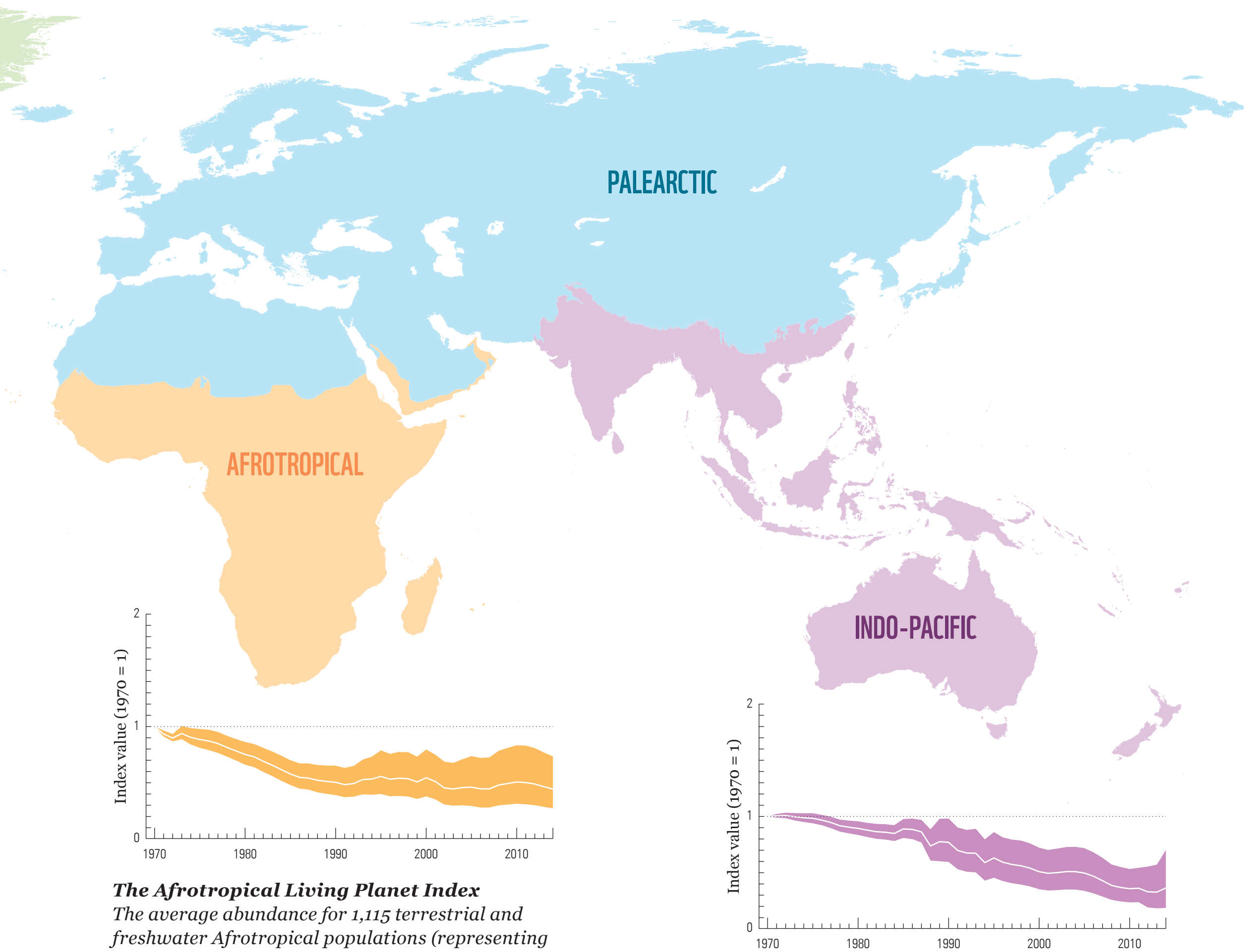
Figure 22: The Living Planet Index for each realm
The white line in the LPI graph shows the index values and the shaded areas represent the statistical certainty surrounding the trend (95%). Threat data is available for 3,789 – just under a quarter – of the populations in the global LPI[1]*. This is explored in chapter 2.*



The Neotropical Living Planet Index
The average abundance for 1,040 populations (representing 689 species) in the Neotropical biogeographic realm. Vertebrate populations declined by an average of 4.8% annually between 1970 and 2014, translating to an overall decline of 89%. This represents the most dramatic change in any biogeographic realm[1].

The Palearctic Living Planet Index
The average abundance for 2,866 terrestrial and freshwater populations (representing 576 species). These populations declined by 31% (-6% to -50%) between 1970 and 2014[1].





The Afrotropical Living Planet Index
The average abundance for 1,115 terrestrial and freshwater Afrotropical populations (representing 320 species). These populations declined by 56% between 1970 and 2014. The decrease was particularly steep in the 1980s[1].

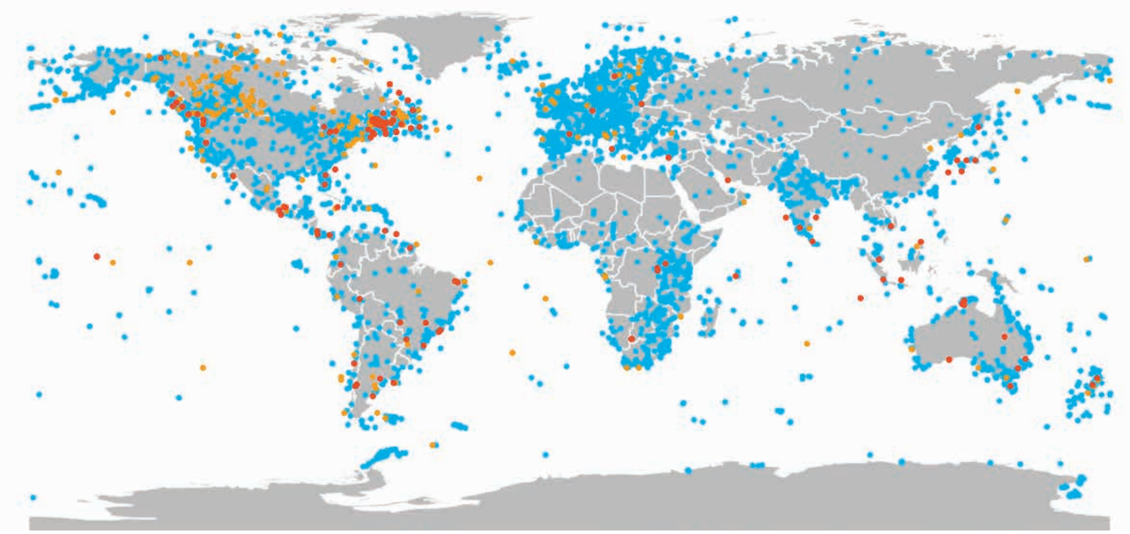
The Indo-Pacific Living Planet Index
The average abundance for 1,083 terrestrial and freshwater populations (representing 488 species) in the Indo-Pacific biogeographic realm. The Indo-Pacific Index experienced the second most pronounced decline, after the Neotropical index: 64% overall between 1970 and 2014[1].

Where does the data come from?

The LPI is calculated from data collected at regular intervals over time on populations of mammal, bird, fish, reptile and amphibian species from around the world. These data are gathered from a variety of sources such as journals, online databases and government reports.

Each edition of the *Living Planet Report* takes advantage of an ever-increasing number of data records. Results reported here are based on 16,704 populations of 4,005 different species – with 319 species making their LPI database debut. The majority of these additional populations are from North America but focused data collection has also improved representation in the Indo-Pacific and Afrotropical realms (figure 23). The largest enhancement, of more than 4%, can be seen in reptile species in Australasia and Oceania (Indo-Pacific realm), followed by mammal species in the Neotropics and the Nearctic. The baseline year is always 1970 but the cut-off year advances as more data is gathered and becomes available. This year's cut-off is 2014.

Figure 23: Locations of Living Planet Index species populations
Map showing the locations of the monitored populations in the LPI. Newly added populations since the last report are highlighted in orange, or in red for species new to the LPI[1].



Freshwater Living Planet Index

Freshwater ecosystems provide habitat for at least 126,000, or around 1 in 10, known species of fishes, molluscs, reptiles, insects, plants and mammals [3] despite covering less than 1% of the Earth's surface [4].

These ecosystems are also the most threatened – they are strongly affected by habitat modification, fragmentation and destruction; invasive species; overfishing; pollution; forestry practices; disease; and climate change. In many cases, these combined threats have led to catastrophic declines in freshwater biodiversity [5,6].

The 3,358 populations – representing 880 species of mammals, birds, amphibians, reptiles and fishes – in the Freshwater LPI show an 83% decline, equivalent to 4% per year since 1970. The largest declines are seen in populations in the Neotropics (-94%), the Indo-Pacific (-82%) and the Afrotropics (-75%), especially in reptiles and amphibians, and in fishes.

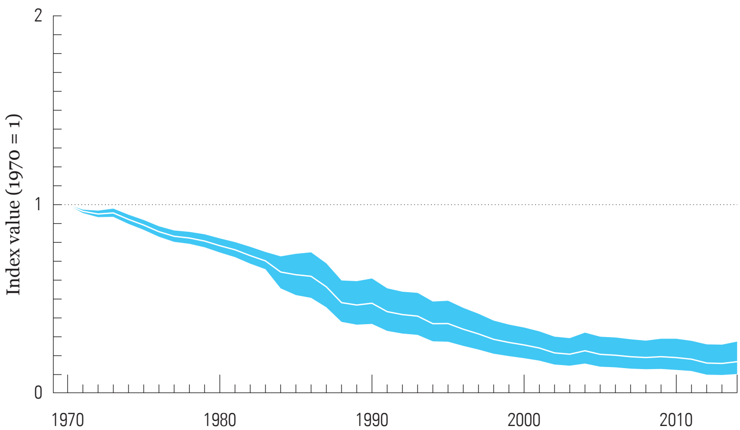


Figure 24: The Freshwater Living Planet Index: 1970 to 2014
The average abundance of 3,358 freshwater populations representing 880 species monitored across the globe declined by 83%. The white line shows the index values and the shaded areas represent the statistical certainty surrounding the trend (range -73% to -90%) [1].

Key

Freshwater Living Planet Index

Confidence limits

CHILDREN AND NATURE

4. River living

The Tonle Sap River in Cambodia connects the Tonle Sap Lake and the Mekong River and is a migration route for many fish, including the critically endangered Mekong giant catfish (*Pangasiandon gigas*). Local children experience the value of this natural system in a very direct way: the river provides them with fresh water, and fish are a critical protein source in their daily diets. With a growing world population, it's expected that by 2050 two-thirds of humanity will live in cities[23] with a less direct relationship to nature than these children.

© Zeb Hogan - WWF

© Dr Lawrence Bellamy - Seabird spotting at Blakeney Point in Norfolk 2016

Dr Ben Collen (1978-2018)

© ZSL - Ben setting up an array of camera traps which captured the first wild footage of Pygmy hippopotamus in Liberia in 2011

We pay tribute to a great scientist, collaborator and friend whose research was and continues to be pivotal to the *Living Planet Report* series.

Ben's research into the impact of a changing environment on the planet's wildlife was central to the science that underpins our understanding of the world and the life it sustains. Having earned his PhD at the Institute of Zoology and Imperial College London from 2002 to 2005, he joined ZSL in 2005 as a Postdoctoral Research Associate. He went on to lead the Indicators and Assessments Unit, during which time he developed the conceptual and analytical basis for the Living Planet Index. During this time, he also advanced our understanding of the extinction risk of many species and helped develop the sampled approach to the Red List Index, a critical tool for assessing the extinction risk of lesser-known taxonomic groups.

In 2013 Ben moved on to become a lecturer, then reader in biodiversity, at UCL's Centre for Biodiversity and Environment Research, but his connection to ZSL remained as a collaborator, and supervisor of many PhD and masters students who valued his leadership, knowledge and support. In 2015 he won the prestigious ZSL Marsh Award for Conservation Biology, which acknowledged his contribution to designing and using biodiversity indicators. By then his innovative approaches had been applied and operationalised with numerous worldwide collaborators. His appointments were many and varied, including as an Honorary Research Fellow for UNEP, and a member of multiple IUCN Red List committees.

Ben's contribution to science is in no doubt. His influential and wide-ranging publications in some of the world's most high-profile journals are a testament to his passion, great talent, and dedication to conservation science. But it is the kindness and sincerity that he brought to his relationships with his friends, colleagues, students and peers that remains with all of us.
Ben brought a great deal of fun and adventure to all that he did, making a mark on all those who crossed his path, and we will miss him dearly.

For two decades the Living Planet Index has set out the state of our planet's biodiversity by tracking a rise or decline in numbers of specific species. Biodiversity has many components, and there is no single measure that can capture all of its changes, so in this LPR we look beyond population abundance and at three other indicators that measure species' extinction risk, changes in species community composition and changes in species distribution. All show severe declines or changes.

DIFFERENT BIODIVERSITY INDICATORS, SAME STORY

Biodiversity: A multifaceted concept requires multiple indicators

Piero Visconti, Zoological Society of London (ZSL) and University College London (UCL)

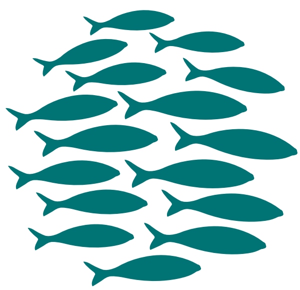
Biodiversity is often referred to as the 'web of life'. It is the variety of all living things – plants, animals and micro-organisms – and the ecosystems of which they are a part. It includes diversity within species and between species and can refer to any geographic scale – from a small study plot to the entire planet[7].

"The biodiversity we see today is the fruit of billions of years of evolution, shaped by natural processes and, increasingly, by the influence of humans. It forms the web of life of which we are an integral part and upon which we so fully depend. It also encompasses the variety of ecosystems such as those that occur in deserts, forests, wetlands, mountains, lakes, rivers, and agricultural landscapes. In each ecosystem, living creatures, including humans, form a community, interacting with one another and with the air, water, and soil around them." Convention for Biological Diversity[8]

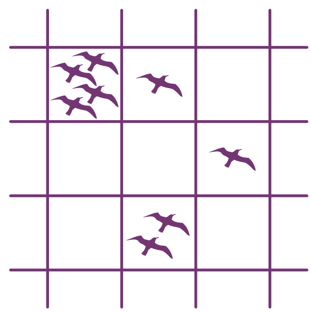
Species, and the natural systems around us, respond to human pressures and conservation interventions in a variety of ways and there is no single measure to capture all these changes. That's why different metrics and indicators are needed to understand biodiversity change as well as to track progress towards biodiversity targets and to devise effective conservation programmes.

In addition, the direction of abundance trends is only available for a minority of species. For example, the IUCN Red List uses information about species-level increases and decreases as one of the criteria for assessing extinction risk. The Database currently contains this information for 60% of mammals, 64% of amphibians, 92% of birds and 52% of the world's reptiles[9]. The magnitude of these trends is known for far fewer species. Other taxonomic groups are even less well-monitored[9]. To compensate for this scarcity of observational data, other biodiversity measures and ecological models can be used to track biodiversity change and inform conservation strategies.

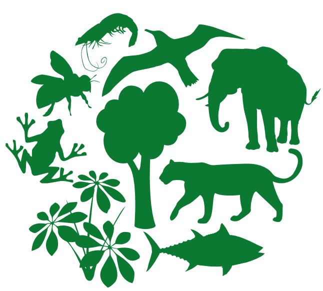
To complement the population-based Living Planet Index and put the trends that it measures in a broader context, we have included in this report an overview of three other biodiversity indicators: the Species Habitat Index, measuring changes in species distribution, the IUCN Red List Index which tracks extinction risk, and the Biodiversity Intactness Index that looks at changes in community composition.



ABUNDANCE



DISTRIBUTION



COMPOSITION

EXTINCTION RISK

Collecting LPI data

The Living Planet Database draws on information from 3,268 data sources. The index is based on relative changes in populations over time so the data can be collected in many ways – ranging from counting the number of individual animals in a herd of wildebeest in Kenya or camera trapping tapirs in Costa Rica and tigers in India, to surveys of nesting sites of songbirds or tracking the traces animals leave behind, for example the tracks of Eurasian lynx in Russia.

Some of these datasets are part of long-term research monitoring programmes. Others are generated as part of citizen science programmes or large-scale monitoring surveys, such as the North American Breeding Bird Survey.

Axel, an intern at The Biodiversity and Education Center, Gamba, replaces a card in a camera trap in Gabon, Africa.

© James Morgan - WWF

PUTTING THE LPI IN CONTEXT

Distribution: the Species Habitat Index

The Species Habitat Index, an aggregate measure of the extent of suitable habitat available for each species, has been proposed as an additional indicator to help provide a richer picture of both past and projected future biodiversity change. This index captures changes in species range and incorporates information about species habitat preferences, observed or modelled data on habitat loss and restoration, habitat fragmentation and climate change. When used together, species distribution and habitat suitability models can estimate the combined impact of habitat loss and climate change on species, in both the past and the future [10-12].

Piero Visconti,
Zoological Society of London (ZSL) and University College London (UCL)

The overall trends in the Species Habitat Index for mammals declined by 22% from 1970 to 2010, with the greatest declines in the Caribbean (>60%). Other regions with declines of more than 25% were Central America, North-East Asia and North Africa [13].

Extinction risk: the IUCN Red List of Threatened Species

Thousands of experts periodically assess the extinction risk of nearly 100,000 species using the criteria and categories of the IUCN Red List. Using information on life-history traits, population and distribution size and structure, and their change over time, Red List assessors classify species into one of eight categories (Extinct, Extinct in the Wild, Critically Endangered, Endangered, Vulnerable, Near Threatened, Least Concern or Data Deficient). As species are reassessed over time, some species may genuinely improve in status owing to conservation action, while others may deteriorate owing to increasing threats. The Red List Index shows the net balance between these factors, and filters out reclassifications owing to improved knowledge or taxonomic revision [14,15].

Stuart Butchart,
BirdLife International

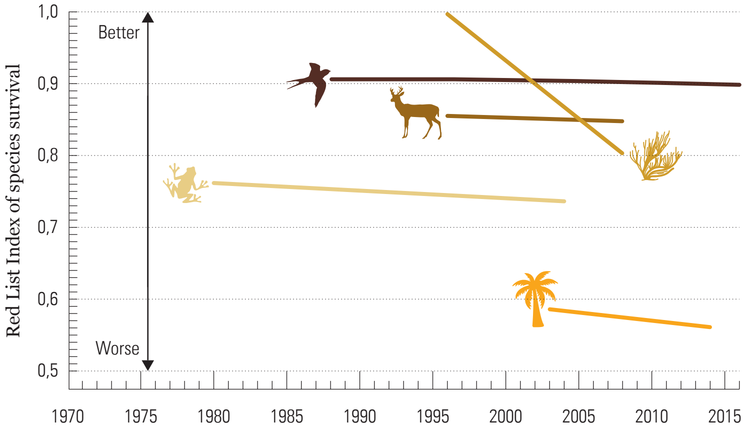
Piero Visconti,
Zoological Society of London (ZSL) and University College London (UCL)

Craig Hilton-Taylor,
IUCN

Figure 25: IUCN Red List Index of species survival for mammals, birds, amphibians, corals and cycads

Key

- Birds
- Mammals
- Corals
- Amphibians
- Cycads



A Red List Index value of 1.0 equates to all species within a group qualifying as Least Concern (i.e. not expected to become Extinct in the near future). An index value of 0 equates to all species having gone Extinct. A constant value over time indicates that the overall extinction risk for the group is unchanged. If the rate of biodiversity loss were reducing, the index would show an upward trend.

Currently, the Red List Index is available for five taxonomic groups in which all species have been assessed at least twice: birds, mammals, amphibians, corals and cycads (an ancient group of plants). Current index values for all groups show declines, indicating that species are moving towards extinction more rapidly.

Thematic versions of the index show that pollinators are in decline (at least among birds and mammals [16]), and that wild relatives of farmed and domesticated species are also declining, potentially threatening future food security through loss of genetic diversity [17].

Composition: the Biodiversity Intactness Index (BII)

Andy Purvis and
Adriana De Palma,
Natural History Museum,
London

Samantha Hill,
UN Environment World
Conservation Monitoring
Centre (UNEP-WCMC)

The Biodiversity Intactness Index (BII) estimates how much of a region's originally present biodiversity remains, relative to if the region were still covered with primary vegetation and facing minimal human pressures.

The BII – as an indicator – has been implemented in the PREDICTS modelling framework [18,19]. It is underpinned by a large global database of local sites facing different pressures [20]. Importantly, the database is reasonably representative in its coverage of both species and terrestrial biomes. With most of the data being on insects and plants, BII is one of the few indicators not predominantly based on vertebrates.

The Index ranges from 100–0% with 100 representing an undisturbed or pristine natural environment with little to no human footprint. The most recent global estimates suggest that the BII fell from 81.6% in 1970 to 78.6% in 2014 [21] (figure 26).

Models that focus on tropical and subtropical forest biomes, using finer-scale land-use data, suggest their BII is both lower and declining more rapidly – from 57.3% in 2001 to 54.9% in 2012 [22] (figure 26). Yet, as alarming as these estimates are, they may be over-optimistic. That's because the PREDICTS framework does not yet incorporate the effects of climate change or the delayed impacts of land-use change and because global land-use data does not distinguish plantations from natural forest [19].

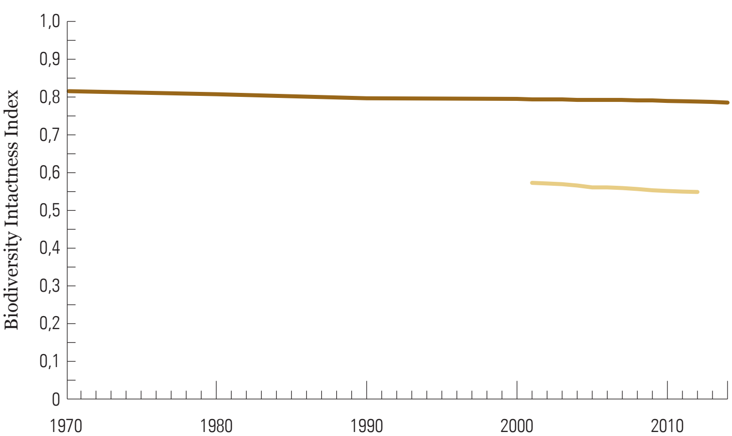


Figure 26: Trends in the Biodiversity Intactness Index (BII)
Dark brown line: Global average BII 1970-2014 from projections made at 0.25-degree scale [20]. Light brown line: Average BII for tropical and subtropical forest biomes 2001-2012 from projections made at 1km resolution [21].

Key

Global (using coarse-scale pressure data)

Tropical forest (using 1km-resolution pressure data)

© National Geographic Stock - Steve Winter - WWF

A camera trap captures an endangered snow leopard (*Panthera uncia*) in Hemis National Park, a high altitude national park in the eastern Ladakh region of the state of Jammu and Kashmir in India.

CHAPTER 4:
Aiming higher: what future do we want?

The immense changes in societies around the globe, especially since the Industrial Revolution, have brought equally immense impacts on nature. Without a dramatic move beyond 'business as usual' the current severe decline of the natural systems that support modern societies will continue – with serious consequences for nature and people. With two key global policy processes underway there is currently a unique window of opportunity to reverse the trend – and bend the curve of biodiversity loss. Lessons can be learned from progress towards solving other critical global issues, like climate change, and everyone – governments, business, finance, research, civil society and individuals – has a part to play.

Polar bear jumping on ice, Spitsbergen, Norway.


© Steve Morello - WWF

BENDING THE CURVE OF BIODIVERSITY LOSS

Georgina Mace, University College London (UCL)

Mike Barrett, WWF

Neil Burgess, UN Environment World Conservation Monitoring Centre (UNEP-WCMC) and the University of Copenhagen

Sarah E. Cornell, Stockholm Resilience Centre (SRC)

Robin Freeman, Zoological Society of London (ZSL)

Monique Grooten, WWF

Andy Purvis, Natural History Museum, London

Biodiversity has been described as the 'infrastructure' that supports all life on Earth. The natural systems and biochemical cycles that biological diversity generates allow the stable functioning of our atmosphere, oceans, forests, landscapes and waterways. They are, simply, a prerequisite for our modern, prosperous human society to exist, and to continue to thrive [1,2].

The Rio de Janeiro Earth Summit in 1992 was a critical landmark in mankind's relationship with nature. For the first time the global community came together and collectively agreed on the importance of the natural world and our responsibility to protect it. In the quarter-century since then, there have been some successes – the recovery of great whale populations and the huge growth in protected areas among them. But these remain isolated wins and, as this report makes clear, the continued decline in species shows that we have failed the natural world. Many of these changes have been driven by a spiralling increase in our consumption. This has now reached a scale whereby it is interfering profoundly with biodiversity and all the other natural systems.

This degradation of nature is among the most serious issues that the world faces, but current targets and consequent actions amount, at best, to a managed decline. This chapter is inspired by a paper that was conceived during the brainstorming for this anniversary edition of the *Living Planet Report* and published on 14 September 2018 in *Nature Sustainability*. The paper – 'Aiming Higher – bending the curve of biodiversity loss' [3] – argues that what the world requires is bold and well-defined goals and a credible set of actions to restore the abundance of nature to levels that enable both people and nature to thrive. In the paper – and this chapter – the authors stress that without this dramatic change in efforts to reverse the Earth's ongoing biodiversity decline, the persistent failure to meet conservation and biodiversity targets is likely to continue. If this trend is not reversed there is a question as to whether the Agenda 2030 Sustainable Development Goals (SDGs) can be achieved, including mitigating climate change [4], adapting to climate impacts [5], maintaining the quality of soil, air and water, and supporting a resilient basis for the food, fuel and fibre that future generations of people will need [6].

WE NEED TO AIM HIGHER, AND DO BETTER, TO PROTECT AND RESTORE OUR LIFE SUPPORT SYSTEMS – TO BEND THE CURVE OF BIODIVERSITY LOSS. THIS MEANS GOING BEYOND BUSINESS AS USUAL

A unique opportunity

SETTING A CLEAR GLOBAL BIODIVERSITY TARGET, TURNING OUR KNOWLEDGE INTO GREATER ACTION FOR BIGGER IMPACT

Between now and the end of 2020, there is a unique window of opportunity to shape a positive vision for nature and people. The Convention on Biological Diversity (CBD – see box 1), is in the process of setting new goals and targets for the future. These, together with the Sustainable Development Goals, will become the key international frameworks for protecting nature and enhancing biodiversity.

Existing CBD goals and targets are to be achieved by 2020. The 196 countries that are parties to the Convention are currently working on a post-2020 strategic plan with new goals and targets. This provides a vital opportunity to create a bold and achievable plan of action. If the loss of biodiversity is to be halted and reversed, this opportunity must be seized.

Although the CBD has a vision for 2050 (box 1), currently there are no biodiversity policy commitments beyond 2030. However, because of the nature of the challenge we face, it's critical to consider a longer timescale. When wildlife populations and habitats are damaged, or lost, some kinds of recovery can take decades. Also, the intensity of some threats, such as climate change, will increase after 2030. Climate change targets are routinely set for 2050 and 2080, recognizing the long-term dynamics of the climate system. Species and ecosystems also demonstrate dynamics that may play out over decades to centuries, hence longer-term goals, supported by policy commitments, are also crucial.

Despite numerous international scientific studies and policy agreements confirming that the conservation and sustainable use of biological diversity is a global priority, worldwide trends in biodiversity continue to decline. Figure 27 shows starkly how poorly natural systems have fared since internationally agreed policy commitments such as the CBD targets came into force. However, it also offers a vision for the future: if we aim higher and move away from business as usual, implementing approaches designed to restore nature rather than simply tracking a managed decline, then we can achieve a healthier, more sustainable world that is good for people as well as our natural systems.

This chapter uses text and ideas from a paper published by the chapter authors in *Nature Sustainability* on the 14th September 2018: Mace, G. M. et al. Aiming higher to bend the curve of biodiversity loss. *Nature Sustainability* **1**: 448-451, doi:10.1038/s41893-018-0130-0 (2018).

Box 1: The Convention on Biological Diversity and the Aichi Targets

At the 1992 Rio Earth Summit, two binding agreements were initiated: the United Nations Framework Convention on Climate Change (UNFCCC) and the Convention on Biological Diversity (CBD). The CBD was the first global agreement on the conservation and sustainable use of biological diversity and came into force in 1993. Every country in the world, except the USA, is now a Party to the Convention. While the CBD sets overall goals and policies with general obligations, the responsibility for achieving these goals rests largely with countries themselves.

The current CBD Strategic Plan for Biodiversity (2011-2020) is intended to be an overarching framework for biodiversity conservation, not only for the biodiversity-related conventions, but for the entire UN system and all other partners engaged in biodiversity management and policy development. The plan includes a long-term vision:

"By 2050, biodiversity is valued, conserved, restored and wisely used, maintaining ecosystem services, sustaining a healthy planet and delivering benefits essential for all people."

To meet this vision the CBD, through agreement with the Parties, has developed a set of five medium-term strategic goals with 20 targets – called the Aichi Targets.

Goal C is "To improve the status of biodiversity by safeguarding ecosystems, species and genetic diversity" and includes three targets.

Target 11 concerns the global coverage of protected areas

Target 12 is directed at the conservation of species

Target 13 concerns the conservation of genetic diversity of cultivated plants, farmed and domesticated animals, and their wild relatives

Target 12 is the most direct and straightforward measure of biodiversity, and metrics exist at global scale that have already been adopted by the CBD in various assessment processes. It states, "By 2020 the extinction of known threatened species has been prevented and their conservation status, particularly of those most in decline, has been improved and sustained." The target is only directed at "known threatened species" – those listed as Critically Endangered, Endangered or Vulnerable on the IUCN Red List (www.iucnredlist.org). In 2017 this was just over 25,000 species, out of over 60,000 that have been assessed for the Red List. Note that this is only a small proportion of all known species (more than 1.3 million) and a sample that is strongly biased towards terrestrial and large-bodied vertebrates.

To meet Target 12, none of these threatened species should have gone extinct, and those species in steepest decline should show improvements in their status by at least moving to a category of lower threat (see Chapter 2 for more details about these categories).

The Strategic Plan for the Convention on Biological Diversity (2010–2020) includes the 20 Aichi Targets to be achieved by 2020. Recent projections suggest that this is unlikely for most of the targets [8]. Yet the 2050 vision requires a much more ambitious goal, which will necessitate recovery of biodiversity and bending the curve by 2030. The black line indicates currently observed trends (to 2015), dotted lines show extrapolations from current trends (black) and projections for biodiversity after 2030 that are declining (red), stabilizing (orange) or recovering (green).

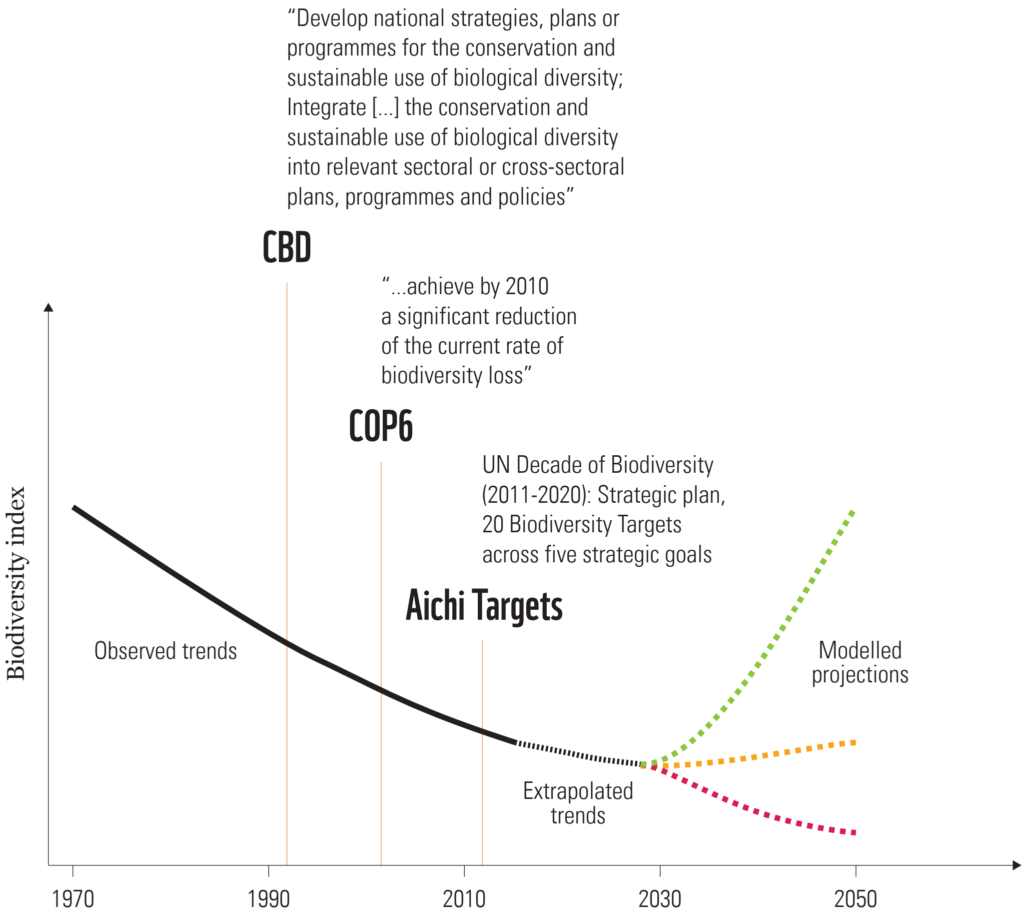


Figure 27: Biodiversity declines have continued despite repeated policy commitments aimed at slowing or halting the rate of loss
(redrawn from Mace et al. 2018 [3]).

Box 2: The UN Sustainable Development Goals

On 1 January 2016, the 17 Sustainable Development Goals (SDGs) with their accompanying 169 targets came into force. These underpin the UN-led 2030 Agenda for Sustainable Development. Collectively, they represent a hugely ambitious blueprint for the sustainable future of humanity on this planet with the aspirational pledge "that no one will be left behind". Critically, they are defined as being "integrated and indivisible", meaning that countries are not able to pick and choose which elements to address but must work towards the achievement of them all. Collectively, they also balance the three dimensions of sustainable development: environmental, social and economic. The stated aim is that the SDGs will be delivered by 2030, although some targets, and especially the environmental targets, have end dates of 2020.

Within the preamble the signatories declare that they will "protect the planet from degradation, including through sustainable consumption and production, sustainably managing its natural resources and taking urgent action on climate change, so that it can support the needs of the present and future generations".

This commitment is translated into 3 of the 17 goals that are specifically directed at the natural world:

Goal 13 (Climate change): Take urgent action to combat climate change and its impacts.

Goal 14 (Life below water): Conserve and sustainably use the oceans, seas and marine resources for sustainable development.

Goal 15 (Life on land): Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.

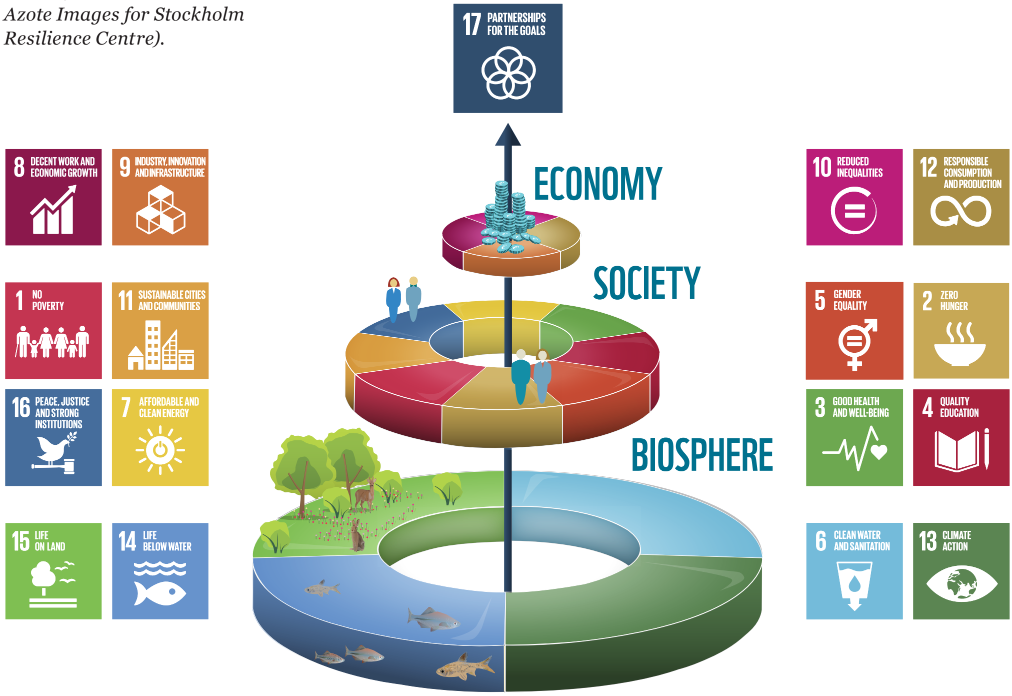
Both Goals 14 and 15 have specific targets directed at reducing threats, securing ecosystem functions and services, and supporting the flows of benefits from biodiversity to people. One target in Goal 15 concerns the state of biodiversity itself ("Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species"). This target reflects Aichi Target 12. There is no equivalent target in Goal 14 (Life below water) but we can infer that the goal of halting biodiversity loss also applies to species living in the oceans.

Halting biodiversity loss is a more ambitious target than the Aichi Target of preventing the extinction and improving the status of known threatened species, because it concerns all species and is not restricted to extinction risk alone. Halting the "loss of biodiversity" should be interpreted as also halting declines in abundance and distribution of species, as well as the structure and functioning of biological communities.

Collectively, the Sustainable Development Goals aspire to take us towards 'the world we want' and the UN frames them as creating a "blueprint to achieve a better and more sustainable future for all". Figure 28 explores these SDGs in more detail. Although the 17 Goals are presented separately, they are not independent of each other. Johan Rockström and Pavan Sukhdev modified an infographic developed by the science director of the Stockholm Resilience Centre, Carl Folke, and others to present new way of viewing the Sustainable Development Goals and to show how they are all linked to food.

This framework emphasizes that, given pressing needs to simultaneously avoid dangerous climate change, feed the world's growing population and restore biodiversity, cross-cutting solutions are crucial. These must enable our land and oceans to support all three objectives effectively and equitably, while recognizing the interactions and interdependencies between them that offer opportunities as well as risks.

Figure 28:
The intertwined nature of the biosphere, our society and our economy, and by extension the SDGs that are designed to effect progress within those systems (credit: Azote Images for Stockholm Resilience Centre).



Box 3: Global biodiversity commitments to 2020, 2030 and 2050 enshrined in the CBD and SDG frameworks

Convention on Biological Diversity

By 2050, biodiversity is valued, conserved, restored and wisely used, maintaining ecosystem services, sustaining a healthy planet and delivering benefits essential for all people (CBD vision).

CBD Aichi target 5: By 2020, the rate of loss of all natural habitats, including forests, is at least halved and where feasible brought close to zero, and degradation and fragmentation is significantly reduced.

CBD Aichi target 12: By 2020 the extinction of known threatened species has been prevented and their conservation status, particularly of those most in decline, has been improved and sustained.

Sustainable Development Goals

SDG 14: Conserve and sustainably use the oceans, seas and marine resources.

SDG 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.
Target 15.5: Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity, and protect and prevent the extinction of threatened species.

NB. Although the SDGs are set to 2030, some biodiversity-related targets give 2020 as an end date. Given the difficulty of abruptly halting current trends, we suggest 2030 for the two biodiversity-related SDG targets.

A roadmap for 2020 to 2050

As well as the existing global targets, many regional, national and local initiatives and projects aim to protect biodiversity. Given the continuing loss of nature as shown in figure 27, however, it's clear that these efforts are not enough. So, what will it take to 'bend the curve' of biodiversity loss?

We can learn lessons from other critical global issues as we develop a roadmap for reaching biodiversity goals and obtaining national commitments with appropriate levels of ambition. For climate change, the world has mobilized around one clearly specified goal – keeping global warming below 2°C. Future climate targets are based on scenario analyses that identify the most impactful suite of actions to achieve this long-term goal. For example, the climate stabilization 'wedges'[9] were developed as a portfolio of available technologies that could collectively achieve the necessary cuts in greenhouse gas emissions over a 50-year period. The wedge approach has also been successfully applied to other environmental challenges, such as water stress[10].

The SDG process has similarly focused on motivating societal engagement around its 17 goals, building buy-in for an integrated agenda. Both agreements explicitly recognize that the status quo is not an option and instead set necessarily hard-hitting global targets to reverse business-as-usual trends.

In the *Aiming Higher* paper, the authors suggest three necessary steps in a roadmap for the post-2020 agenda: (1) clearly specify the goal for biodiversity recovery, (2) develop a set of measurable and relevant indicators of progress, and (3) agree a suite of actions that can collectively achieve the goal in the required timeframe. Here we describe each of them.

Step 1: Translate the aspirational vision to an ambitious goal

The first step in the development of a biodiversity roadmap is to specify the goal.

The current CBD vision is that "By 2050, biodiversity is valued, conserved, restored and wisely used, maintaining ecosystem services, sustaining a healthy planet and delivering benefits essential for all people."

When it was written, it was an aspirational vision for the future. The *Aiming Higher* paper argues that this vision is concrete and achievable enough to be the basis of the goal of a post-2020 agreement on biodiversity. Achieving this ambitious goal will require a new set of targets that aim higher and are effective beyond 2020.

Step 2: Identify ways to measure progress towards the goal

Keeping track of the status of biodiversity, and progress towards targets, requires suitable indicators. Since the current targets were set, almost a decade ago, there has been an explosion of these, so the second step is to identify the best metrics to measure true progress towards the chosen goal.

Measuring progress towards biodiversity targets is more complicated than tracking progress under the Paris Climate Agreement on greenhouse gas emission reductions. Biodiversity assessment requires multiple measures at different spatial scales and across different ecological dimensions. The different metrics that are in common use capture different properties of biodiversity, and their responses to pressures vary [11]. Mace et al. has argued for indicators that can track three key dimensions of biodiversity necessary for the vision and the goals described here, and in the CBD and SDG targets:

1) Changes in population abundance: Trends in the abundance of wild species are well captured by population-level indicators such as the Living Planet Index (LPI) [14]

2) Extinction rate on a global scale: The extent to which species are threatened with the risk of extinction is estimated by the Red List Index (RLI) [12,13]

3) Changes to local biodiversity: Changes in the ‘health’ of ecosystems can be estimated by comparing what currently exists with what once existed in a given place using indicators such as the Biodiversity Intactness Index (BII) [15,16]

The required trajectories for these three biodiversity indicators are shown in figure 29.

Figure 29 illustrates how each of these indicators would respond – or their trajectories would change – in a world where the policy goals and targets in Box 3 are met and nature is recovering.

Figure 29: *Required trajectories for the three proposed biodiversity indicators reflecting conservation status (i.e. global extinction risk), population trend (changes to average population abundance) and biotic integrity (changes to local, functional diversity) from the present to 2050, based on the commitments in Box 3. These curves would represent a successful recovery and restoration of nature. Note that while the curves are based on recent data and analyses they are necessarily approximate and so the indicator axes do not have figures attached to them.*

The two top graphs show lines for both threatened and all species because preventing extinction is the aim of the current Aichi Target 12 and is an absolute measure of conservation success or failure.

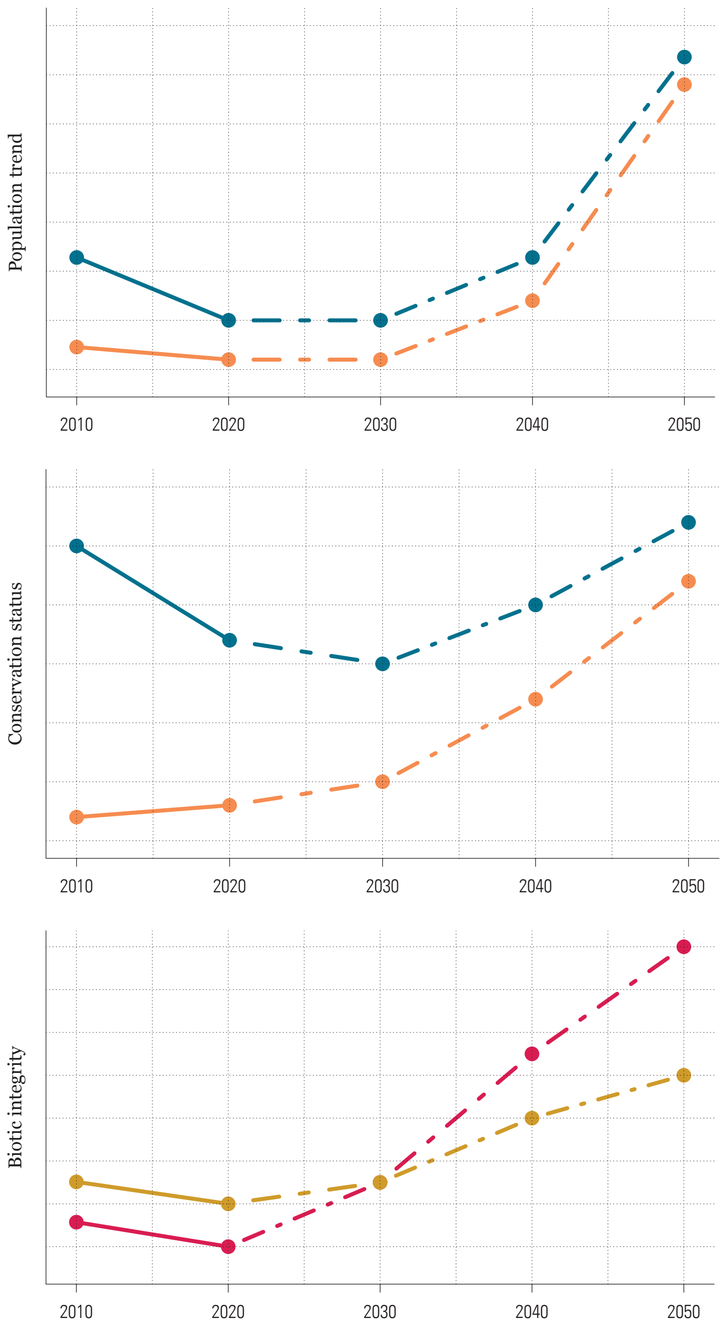
Key

All species
Threatened species

In the bottom graph, we have included biomes as tracking changes to biomes is critical to Aichi Target 5. There is also a line for ecoregions, as these are used within Target 11 as part of the element on protected areas and to ensure that biodiversity in different areas of the world is equally represented (see boxes 1, 2 and 3 for more information about all these targets).

Key

Biomes
Ecoregions



These three indicators are by no means the only indicators that could be used. However, they have the advantage of already being applied widely in the scientific and policy communities and of being globally relevant and robust. Their methodologies have been peer-reviewed for scientific publication. There is extensive data behind each one, with global coverage; and they have open-access methods and datasets that are continually being refreshed and expanded. If they are to be used to support concrete global action, there is a need to improve taxonomic representativeness, integration and data coverage. A clear policy process could act as a spur to improve and build on the underlying datasets.

Step 3: Identify actions to deliver the required transformation in global biodiversity

Scenarios and models can help scientists to visualize and explore how alternative actions affect the dynamic interdependencies between nature, nature's benefits to people and quality of life. The *CBD Global Biodiversity Outlook 4* report represents one of the more recent authoritative assessments of biodiversity status and trends [17]. Scenario and projection models have also started to explore future biodiversity impacts associated with climate change scenarios [18] as well as scenarios where the Sustainable Development Goals are met through changes in factors such as production, consumption, waste, protected areas and forestry [19,20].

Global projections, scenarios and models of ecosystems provide insights into the trajectory of change in biodiversity and ecosystem services over the coming century on land, in the sea and, still to a much lesser extent, in fresh water (reviewed in Tittensor et al. 2017 [21]). However, the challenge we face is that we not only need to identify potential pathways that will allow us to restore biodiversity, we also need to achieve the necessary transformation while feeding a still-growing population under the accelerating effects of climate change in a rapidly changing world. Therefore, although traditional biodiversity conservation interventions such as protected areas and species conservation planning remain crucial, action must also address the major drivers of biodiversity loss and ecosystem change, such as agriculture and overexploitation.

Guided by these analyses, integrative policies for sustainable consumption and production (such as changing modern (Western) diets to contain less meat) can benefit biodiversity, climate and food supply [22]. Their role in policy-making is examined in more detail in the next section.

© Wild Wonders of Europe / Konrad Wothe / WWF

Male roe deer (*Capreolus capreolus*) in flower meadow with Siberian irises (*Iris sibirica*) Eastern Slovakia, Europe.

How scenarios can imagine the future and help to create good policy

David Leclère, International Institute for Applied Systems Analysis (IIASA)

Scenario analysis and modelling play an important role in building visions of the future based on different policy choices and actions. Models are simplified representations of the real world, based on available knowledge. They allow exploring the possible future states of biodiversity, under a set of assumptions concerning future human actions and environmental conditions, referred to as scenarios. As such, scenarios and models are vital tools for building a biodiversity roadmap, and can be used to combine the best available scientific, indigenous and local knowledge in assessments and to support decision-making at various stages of the policy cycle (Figure 30).

Exploratory scenarios can help set an agenda by examining a range of plausible futures, often based on possible storylines. These provide a means of framing what to expect in the future and with level of certainty, depending on which storyline materializes or how uncertain our knowledge is.

Intervention scenarios show alternative ways to reach an agreed-upon target.

Target-seeking scenarios inform the policy design phase by exploring what actions and preconditions could allow reaching a given target. During policy implementation, policy-screening scenarios can represent potential outcomes of alternative policy options.

Retrospective policy evaluation provides a gap analysis by comparing the observed trajectories of implemented policies to scenarios that would have achieved the intended target.

Models and scenarios can help in designing policy roadmaps [23], but their use in contexts that link nature and human wellbeing has so far been hampered by the complexity associated with projections of pressures, subsequent biodiversity responses [24], and how these would would affect human wellbeing. In addition, the many targets of the sustainable development agenda are interrelated, and identifying actions that avoid trade-offs and exploit synergies remains remains challenging in terms of how much knowledge needs to be integrated. More comprehensive models are therefore needed and foundations for this work are under way through initiatives such as the IPBES Modelling and Scenarios Task Force and specific projects such as the climate change-oriented Inter-Sectoral Impact Model Intercomparison Project (reviewed in Tittensor et al. 2017 [21]). These will need to be scaled up and broadened to incorporate biodiversity as an integral component of the models, to better represent interactions between ecological, social and economic factors but also to increase their relevance for various stakeholders at multiple scales.

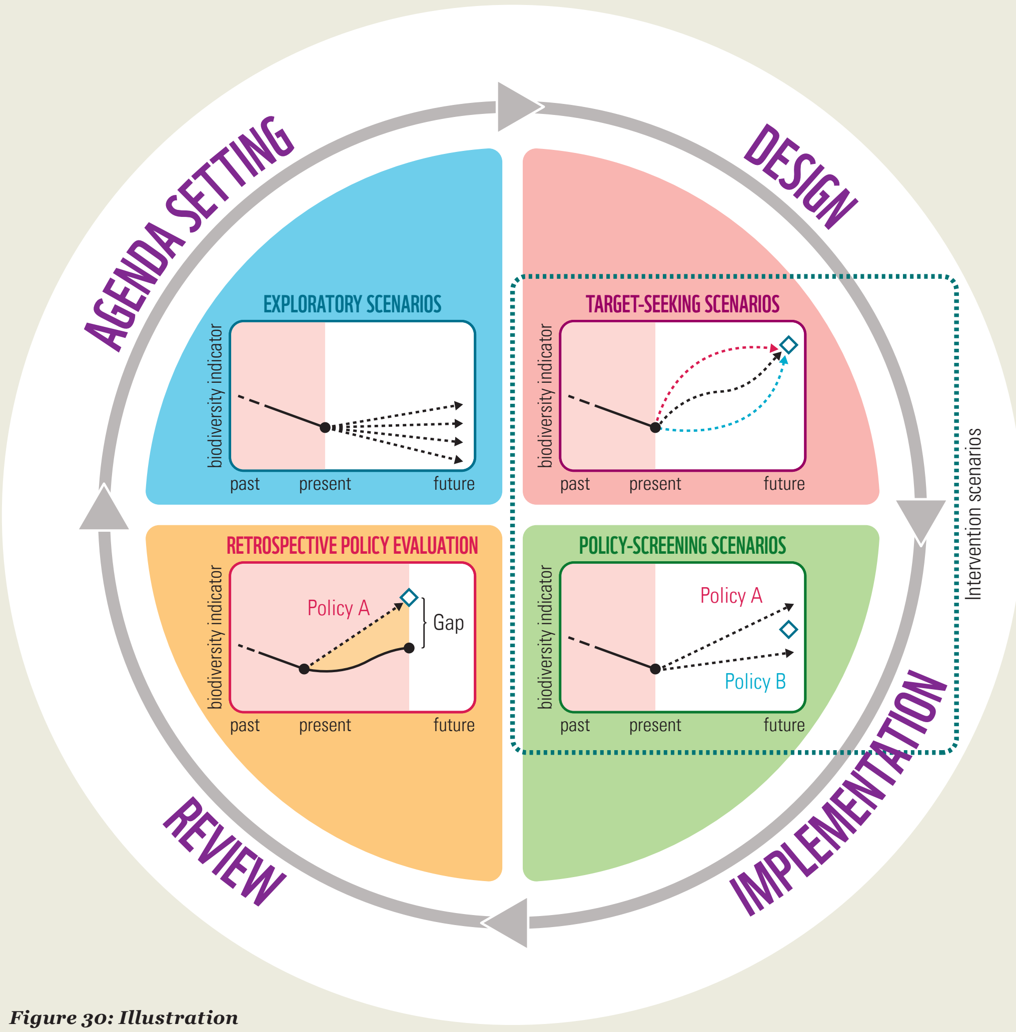


Figure 30: Illustration of the use of models and scenarios at various stages of the policy cycle

In all cases, models mobilize available knowledge to link future biodiversity states to assumptions about future actions or environmental conditions. These can then be explored using different scenarios. Figure reproduced from [25].

MODELS AND SCENARIOS CAN HELP IN DESIGNING POLICY ROADMAPS AND IDENTIFY POTENTIAL WIN-WIN SOLUTIONS FOR BOTH NATURE AND FOR PEOPLE

THE PATH AHEAD

The evidence becomes stronger every day that humanity's survival depends on our natural systems, yet we continue to destroy the health of nature at an alarming rate. It's clear that efforts to stem the loss of biodiversity have not worked and business as usual will amount to, at best, a continued, managed decline. That's why we, along with conservation and science colleagues around the world, are calling for the most ambitious international agreement yet – a new global deal for nature and people – to bend the curve of biodiversity loss. Decision-makers at every level from individuals to communities, countries and companies need to make the right political, financial and consumer choices to realize the vision that humanity and nature can thrive. This vision is possible with strong leadership from us all.

A male Bengal tiger (*Panthera tigris tigris*) in Kanha National Park, Madhya Pradesh, India.

naturepl.com - Nick Garbutt - WWF

NATURE IS OUR HOME

Reframing the debate

This *Living Planet Report* joins an ever-increasing number of research and policy papers building the case that our planet's natural systems are fundamental to our society. Underpinning our health, wealth, food and security they are core to our existence, not just a 'nice to have'.

This report's Living Planet Index also outlines how much nature we are losing. It shows an overall decline of 60% in species population sizes between 1970 and 2014, while current rates of species extinctions are 100 to 1,000 times higher than the background rate (the extinction before human pressure became a prominent factor). Other indicators measuring different changes in biodiversity all paint the same picture – that of dramatic, continued loss.

Yet, the future of millions of species on Earth seems not to have captured the imagination or attention of the world's leaders enough to catalyse the change necessary. We need to radically escalate the political relevance of nature and galvanize a cohesive movement across state and non-state actors to drive change, to ensure that public and private decision-makers understand that business as usual is not an option.

Between now and 2020, a year when global leaders will make key decisions on biodiversity, climate and sustainable development, we have a unique opportunity to build momentum towards the most ambitious deal yet – one that provides a blueprint for biodiversity and for people to 2050 and beyond.

A global deal for nature and people

Indeed, in 2017, almost 50 conservation scientists challenged the business-as-usual approach, calling for a far more ambitious response to the extinction crisis. They published a paper proposing a new 'Global Deal for Nature' as a "companion to the Paris Climate Agreement to promote increased habitat protection and restoration, national and ecoregion scale conservation strategies, and the empowerment of indigenous peoples to protect their sovereign lands."

As an idea it has fast gained momentum. Bending the curve of biodiversity loss – with a new framework for biodiversity that can start to reverse the loss of nature by 2030 – needs to be at its core. Such a deal is essential not just for nature but for people too, because addressing the decline in natural systems is key to achieving the 2030 agenda for Sustainable Development and the Paris Agreement on Climate Change.

Imagining the future: Scenarios and leadership for the future we want

In our contribution to this ambitious pathway, WWF is collaborating with a consortium of almost 40 universities, conservation organizations and intergovernmental organizations to launch the research initiative Bending the Curve of Biodiversity Loss.

Models and scenarios can assist in mapping the best path ahead. This critical work will explicitly include biodiversity in future systems modelling, helping us to identify potential win-win solutions for both nature and people. These new models will form the cornerstone of a future edition of the *Living Planet Report*.

We are proud to be a part of this collective initiative. We all need to embrace this ambition. Piecing together the biggest threats to nature means that we can better protect it. Not much time is left.

WE ARE THE FIRST GENERATION THAT HAS A CLEAR PICTURE OF THE VALUE OF NATURE AND THE ENORMOUS IMPACT WE HAVE ON IT. WE MAY ALSO BE THE LAST THAT CAN ACT TO REVERSE THIS TREND. FROM NOW UNTIL 2020 WILL BE A DECISIVE MOMENT IN HISTORY.

CHILDREN AND NATURE

5. Celebrating nature

In Southern Myanmar this local community is celebrating seven new community forests in the region with a traditional Karen dance, and children are encouraged to participate. Ceremonies are an important part of almost all traditional cultures. In some cases they celebrate a good harvest, others strengthen connections with less visible aspects of the environment, such as holy places.

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References page 143

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WWF International
Rue Mauverney 28
1196 Gland, Switzerland
www.panda.org

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www.zsl.org/indicators
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