Research Fund

Biodiversity at risk

Preserving the natural world for our future

AXA Research Guide Series

Foreword

Climate change has made headline news and the top of the political agenda over the past years and is, rightly so, at the foreground of the most pressing issues facing society today. Another just as, if not more, pressing issue, biodiversity, is also gaining momentum.

Biodiversity is the network of animals and plants that produces oxygen, regulates water, retains soil and provides flood protection – amongst other vital services of considerable value and on which life depends. It also has social, cultural and spiritual significance. These natural resources and associated 'eco-systemic' services are not infinite, and their loss can hugely affect economic and social stability, which is why current indicators are concerning. Almost one third of birds in North America have disappeared since the 1970's[1], a study in Germany's insect population points to a decline of 76% in the biomass of flying insects over the past 25 years[2], Bluefish Tuna stocks are down to 3% of their historic population[3]. And, accordingly to the World Wildlife Fund (WWF) 27 soccer fields worth of forest are lost every minute – an estimated 18 million acres per year.

The acknowledgement of the need to act in the area of biodiversity loss has led AXA, as a responsible private sector player and a leading insurer, to publish a study, with the WWF[4], that calls for the implementation of a Task Force on Nature Impact disclosures to analyze the impact of firms' activities on biodiversity, determine favorable actions for its protection and restoration and provide a measurement tool for investment portfolio effects. This has resulted in a G7 charter on intensified efforts to respond to the biodiversity loss challenge, and efforts are ongoing to provide additional commitments and goals.

To further explicit the importance of maintaining healthy natural ecosystems and find ways to mitigate the challenge of their loss, the AXA Research Fund, AXA's scientific philanthropy initiative, has supported over 60 projects that address the environmental, societal and economic effects of biodiversity loss. This Research Guide aims to highlight the critical nature of biodiversity and the interdependencies between nature, climate change, the economy and security by sharing the insights from AXA Research Fund supported scientists and biodiversity and climate change experts. It also sheds light on some of the steps AXA has engaged in as a private sector player, as a first effort to rise to the challenge of possibly one of the biggest issues facing us yet.

Marie Bogataj, *Director of the AXA Research Fund*

[1] K. Rosenberg et al. "Decline of the North American avifauna," *Science*, 2019.
[2] Hallmann et al, PLOS, 2017.
[3] International Scientific Committee for Tuna, 2018.
[4] WWF France, AXA, *Into the Wild: Integrating nature into investment strategies*, 5-6 May 2019.

Content

FOREWORD ..... p. 2

EXECUTIVE SUMMARY ..... p. 4

INTRODUCTION

THE VALUE OF BIODIVERSITY ..... p. 8

RESEARCHERS AND EXPERTS ..... p. 9

1. BIODIVERSITY LOSS: WHAT IS AT STAKE?

NATURE UNDER THREAT ..... p. 14

BIODIVERSITY & CLIMATE CHANGE ..... p. 18

BIODIVERSITY & SECURITY ..... p. 26

BIODIVERSITY & THE ECONOMY ..... p. 34

2. CHANGING THE WAY WE DO BUSINESS: AXA AND BIODIVERSITY LOSS MITIGATION

CHANGING THE WAY WE DO BUSINESS ..... p. 44

BIODIVERSITY AND INSURANCE ..... p. 48

BIODIVERSITY AND INVESTMENT ..... p. 52

ABOUT THE AXA RESEARCH FUND ..... p. 56

REFERENCES AND ABBREVIATIONS ..... p. 57

ACKNOWLEDGEMENTS ..... p. 59

Executive Summary

The AXA Research Fund aims to stress the critical nature of biodiversity through its latest publication, *Biodiversity at Risk: Preserving the natural world for our future.* This is a collection of interviews, articles and desk research that discuss the interdependencies between nature, climate change, the economy and security, based on insights from AXA Research Fund supported scientists and biodiversity and climate change experts. The report also provides an overview of AXA's commitments in the area of biodiversity loss mitigation and resilience strategies.

Biodiversity and climate change

Climate change is causing widespread damage to ecosystems and has been identified as one of the main drivers of biodiversity loss, behind habitat destruction, invasive species, pollution and overexploitation of natural resources.

While plants and animals have adapted fast to previous periods of warming on Earth, the current acceleration of temperature rise in a very short timeframe (+1°C since pre-industrial times) represents an unprecedent challenge for the resilience of plant and animal species, altering their lives in ways we are only just beginning to understand.

Alongside oceans, forests and soils represent major carbon sinks that significantly mitigate climate change. In addition, tropical forests are critical biodiversity areas. Deforestation, driven by economic development and international trade, therefore threatens both the stability of the global climate and the survival of species: when trees burn down, they release the carbon they have stored, hence contributing to warming. Deforestation also destroys habitats and removes the bridges connecting the different ecosystems.

Initiatives bringing together the private sector, governments, local communities and NGOs – such as reforestation, raising the water table in peatland, and moving to lower-intensity agriculture – have the potential to reduce deforestation, thereby helping mitigate climate change and biodiversity loss.

Biodiversity and security

Natural resources are dwindling due to the unsustainable exploitation of ecosystems to meet the demand for energy and raw materials of an increasing world population, with a projected ten billion people on Earth by the middle of this century.

The rarefaction of resources increases risks to health and food security. An estimated 20%-30% of the world's land is degraded – much of it by crop production, livestock and other forms of agriculture; over 33% of world fish stocks were being fished at unsustainable levels as of 2015 while global food production will have to increase by an estimated 50% by 2050 (compared with 2005) to feed the world's growing population.

Pressures on natural resources favor social unrest and can trigger or magnify conflicts. Migration has increased of

nearly 50% over the past two decades and 40% of all conflicts within states in the last 60 years can be linked directly to natural resources.

In this context, potential solutions to ensure the food safety of a growing world population include moving away from intensive agricultural practices – using less pesticides, changing the way fertilizers are applied, reintroducing more flowers into the countryside and developing 'green' crop species.

Biodiversity and the economy

Biodiversity provides the natural capital that is fueling our economic growth. However, the negative environmental externalities of growth are undermining the sustainability of our economic model and are calling into question traditional measures of wealth and development, such as Gross Domestic Product (GDP).

Measuring the monetary value of biodiversity in spite of methodological uncertainties – especially when it comes to the cultural and spiritual benefits of biodiversity – is a way of conveying the economic argument of biodiversity protection to decision-makers. Based on current estimates, the world's ecosystems provide benefits worth an estimated $125 trillion to $140 trillion a year – the equivalent to more than one-and-a half times global GDP.

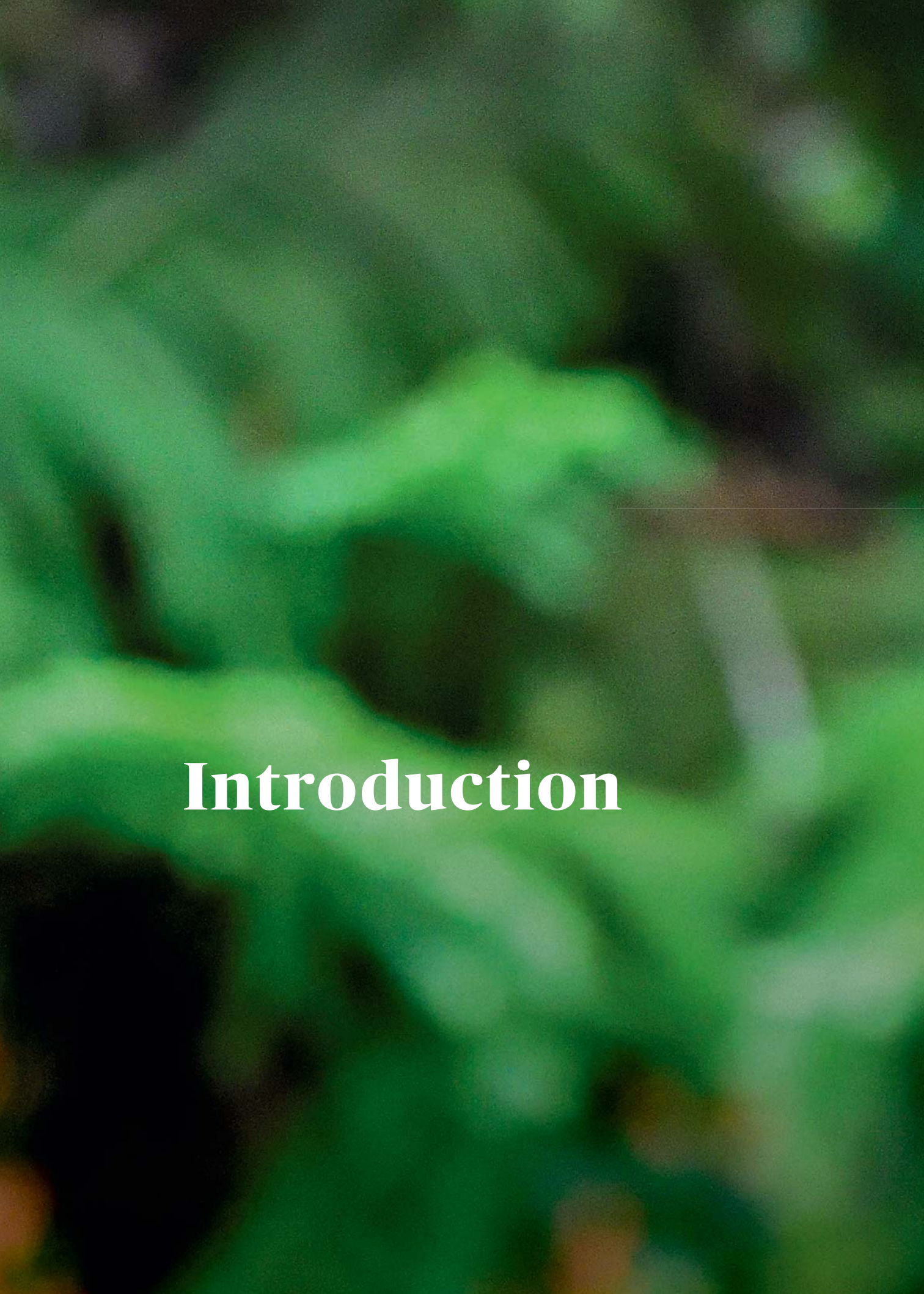
Biodiversity loss will come at a high cost for our economies – habitat loss, pollution, the rise in pests and other invasive species will affect sectors from agriculture, fisheries and forestry to real estate development, tourism and public health. Most at risk will be low-income populations, which rely more widely on natural resources for their income and livelihoods.

Changing the way we do business

The decline in the "natural world" has several implications for the insurance business: In recent years, the stronger intensity of storms, hurricanes, flooding and forest fires, coupled to urbanization, has resulted in more damage and an increase in claims. It also has implications for our health, since biodiversity loss translates into reduced quality and variety of our diets, diminished stocks of natural resources for our medicines, and weakened capacity of ecosystems to provide us with fresh air and clean water. Finally, biodiversity loss is a material issue for the complex supply chains of companies operating in diverse sectors, such as food, agriculture, retail or pharmaceuticals. Through insuring and investing in these companies, the insurance industry is also indirectly exposed to the issue of natural resources.

In the face of these challenges, AXA's strategy operates on several fronts:

- **Insurance:** AXA works directly with customers on environmental risk – the Group provides coverage for companies' liabilities, parametric solutions to the physical impacts of climate change, and offers advice on risk mitigation. AXA is now also looking to develop new, innovative products which include blue carbon credits and insurance for natural systems such as coral reefs and mangroves.
- **Investment:** Biodiversity will be increasingly built into AXA's approach to responsible investment, via the companies the Group invests in and through the launch of a €200 million impact fund for climate and biodiversity towards projects that protect natural habitats and deliver economic and social benefits to local communities.
- **Research:** AXA is committed to scientific research through its scientific philanthropy initiative, the Research Fund, and supports over 60 projects related to biodiversity, for a total of €10 million.
- **Corporate responsibility:** The fight against biodiversity loss will need broad action and requires stronger collaboration between the private and public sectors, as well as NGOs, which often have the expertise and local knowledge necessary for effective policy. In May 2019, AXA issued a series of recommendations jointly with WWF France and urged governments to set clear priorities. This has resulted in a G7 charter on intensified efforts to respond to the biodiversity loss challenge, and efforts are ongoing to provide additional commitments and goals.



Introduction

The value of biodiversity

Biodiversity provides humanity with essential goods and services: the food we eat, the water we drink, the air we breathe, the sequestration of carbon we release through our economic activities and the regulation of the global climate – all depend on the existence of plant and animal life.

Widespread notions of growth and economic progress were built on the assumption that natural resources were infinite at a time when the world supported a population of less than 4 billion people. As a result, economic growth is occurring to the expense of natural capital, which is being depleted at a global scale to meet the demands of a world population that is heading towards an estimated 10 billion by 2050. The associated environmental externalities may be undermining the sustainability of our current economic model and call into question traditional measures of wealth and development such as Gross Domestic Product (GDP). Alternative indicators have been developed to take into account social and environmental aspects. One of these is the Inclusive Wealth Index[5] (IWI) that focuses on how a country manages its total capital stock. This approach reveals that 'real' growth – growth adjusted for natural capital destruction – is substantially lower than headline GDP. In fact, according to the IWI, some countries are growing poorer as the decline in natural capital is outpacing the increase in other forms of capital.

Assessing natural capital and determining how to integrate it into direct economic measures represents a shift in approach and also a practical challenge, due to our limited knowledge about the relationship between ecosystems and the value of the services they provide. Their 'existence value'[6] is equally difficult to quantify with any reasonable level of certainty. In spite of this, Pr. Robert Costanza, from Portland State University and his team proposed a methodology as early as 1997 to value ecosystem services and estimated them at US$33 trillion per year[7]. In 2011, the team updated their initial estimate to US$125 trillion per year[8]. Measuring the monetary value of biodiversity allows us to better assess its importance in terms decision makers are used to.

To better estimate the value of nature and help take appropriate action, it is paramount that we improve our understanding of what is at stake and investigate questions such as the relationship between biodiversity and climate change, the extent to which biodiversity is linked to food security – and, hence, to potential conflicts – the cost of natural capital erosion for our economies and society, and the role that the insurance industry through its underwriting strategies and investment decisions.

[5] The Inclusive Wealth Index is a UN Environment Programme-supported effort that measures the wealth of nations by carrying out a comprehensive analysis of a country's productive base. That is, it measures all of the assets from which human well-being is derived, including manufactured, human and natural capital. In this, it measures a nation's capacity to create and maintain human well-being over time.
[6] The value people derive from knowing biodiversity is there, even if it is never utilized or experienced (Hageman, 1985).
[7] Robert Costanza et al., "The value of the world's ecosystem services and natural capital", in *Nature,* 387 (1997), p. 253-260.
[8] Robert Costanza et al., "Changes in the global value of ecosystem services", in *Global Environmental Change,* 26 (2014), p. 152-158.

Researchers and experts

In putting this Guide together, we have spoken to some of the world's leading authorities in biodiversity, climate change and conservation. Many are from the scientific community and include academics whose work has been supported by the AXA Research Fund. We have also had the privilege to discuss with policymakers, AXA experts and environmentalists to find out how we can work together to address biodiversity loss.

1 **SIR ROBERT WATSON** is a leading international authority on climate change and biodiversity. He was formerly scientific advisor to the United Kingdom's Department of Environment, Food & Rural Affairs. He served as Chair of both the Intergovernmental Panel on Climate Change (IPCC) and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES).

2 **DR. RENÉ CASTRO** served in Costa Rica's government as both Minister for Foreign Affairs and Minister for the Environment and Energy. He has also worked as a consultant for the World Bank and United-Nations (UN). He is now Assistant Director General at the UN's Food & Agricultural Organization (FAO), in charge of climate, biodiversity, land and water.

3 **PR. COLIN PRENTICE** is an internationally-renowned researcher. He specializes in the impact of climate change on the Earth's biosphere. He has also been a major contributor to the IPCC. In 2019, he was named Director at the newly-launched Leverhulme Research Centre for Wildfires, Environment and Society.
AXA Chair in Biosphere and Climate Impacts, Imperial College London, United Kingdom (2012-2019)

4 **DR. COSIMA PORTEUS** is a fish physiologist at the University of Exeter. Her early work focused on the effects on fish of hypoxia, or low oxygen levels. She is currently studying how ocean acidification affects fishes' sense of smell and ability to detect sound.
AXA Post-Doctoral Fellowship at the University of Exeter, United Kingdom (2012-2014)

5 **DR. VINCENT GAUCI** is Professorial Fellow at Birmingham University's School of Geography, Earth and Environmental Sciences. His research focuses on how carbon-dense ecosystems, such as tropical forests and wetlands, interact with the atmosphere through the exchange of greenhouse gas emissions.
AXA project funding at the Open University, United Kingdom (2012-2016)

Researchers and experts

6
DR. DIEGO NAVARRETE is a carbon scientist. He has worked extensively on deforestation and its impact on greenhouse gas emissions, particularly in the Amazon basin. He works for The Nature Conservancy (TNC) as Carbon Specialist for Colombia, Peru and Ecuador.
AXA Ph.D. at University of Exeter, United Kingdom (2012-2015)

7
DR. JEAN-MICHEL VALANTIN is a researcher and author. He has written widely on geopolitics and climate change. His books include Geopolitics of an Unsettled Planet and War and Nature[9]. He heads the Environment and Security team at the think-tank, The Red Team Analysis Society, based in the United Kingdom.

8
PR. ROD A. WING is a leading authority on plant genomics. He was part of the international team that, in 2004, successfully sequenced the rice genome. He currently works with the International Rice Research Institute (IRRI) and is also Director of the Arizona Genomics Institute in the United States.
AXA Chair in Genome Biology and Evolutionary Genomics, IRRI, Philippines (2013-2019)

9
DR. COLINE JAWORSKI's research programme focuses on the interaction between plants and insects. She has published research on pollinator behavior and pest management and is currently working on the impact of climate change on floral scent and pollinators.
AXA Post-Doctoral Fellowship at Aix-Marseille University's Mediterranean Institute of Marine and Terrestrial Biodiversity and Ecology, France (2017-2019)

10
DR. SOPHIA HANSSON is a researcher in eco-geochemistry. She has published papers on the impact of climate change on mountain freshwater ecosystems, and the threat to public health from Japan's commercial whaling. She is currently working in the Pyrenees and Greenland, researching the effect of pollutants from past mining activities.
AXA Post-Doctoral Fellowship at Institut National Polytechnique at Toulouse (2014-2016)

11
PR. GRAEME NICOL focuses his research on soil microbiology and the nitrogen cycle. Based in Lyon, he is also a member of the UK's Royal Society of Biology and a visiting professor of the Chinese Academy of Sciences.
AXA Chair in Ecosystem Engineering and Microbial Ecology at Ecole Centrale de Lyon, France (2014-2020)

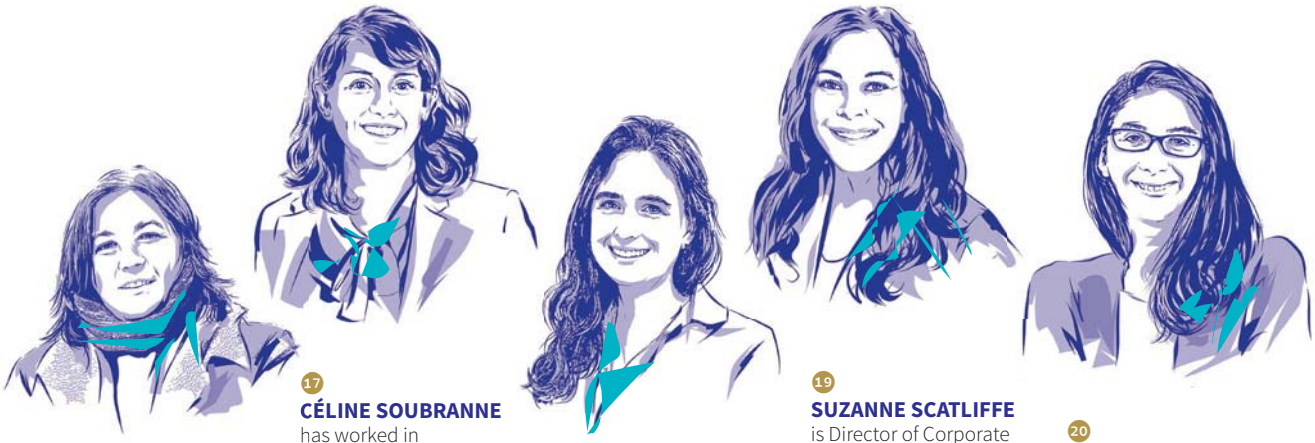
12
WARD HAGEMEIJER joined Wetlands International in 2000. He is currently Head of Business and Ecosystems and has been instrumental in Wetlands International's recent work with the private sector, including the extractives industry. He trained at the Universities of Nijmegen and Groningen, specializing in ornithology and aquatic ecology.

13
DR. KELVIN PEH is Lecturer in Conservation Science at Southampton University. His research focuses on tropical forests and ecosystem services, as well as biodiversity conservation. He has worked extensively on the interaction between humans and wildlife and is also a Visiting Fellow at Cambridge University's Department of Zoology.
AXA Post-Doctoral Fellowship at the University of Cambridge, United Kingdom (2011-2013)

14
PR. FRANCK COURCHAMP is senior researcher at France's National Centre for Scientific Research (CNRS), specializing in population dynamics and conservation biology. He has published on subjects such as invasive species, climate change and the Allee effect[10], and cooperative breeding. He has won the CNRS's silver model and is also a member of the European Academy of Science.
AXA Chair in Invasion Biology, University of Paris Sud (Saclay), France (2019-2024)

15
PR. DIRK S. SCHMELLER is a researcher, based at ENSAT at the Institut National Polytechnique in Toulouse. He notably works on wildlife diseases, biodiversity and the social aspects of conservation. For the past three years, he has coordinated the Belmont-Forum P3 project on mountain ecosystems.
AXA Chair in Functional Mountain Ecology, EcoLab, ENSAT – Institut National Polytechnique, Toulouse, France (2018-2023)

[9] Published in French as *Géopolitique d'une Planète Déréglée* and *Guerre et Nature, 2017.*
[10] Defined as the decline in individual fitness at low population size or density, that can result in critical population thresholds below which populations crash to extinction (F. Courchamp, L. Berec and J. Gascoigne, 2008).



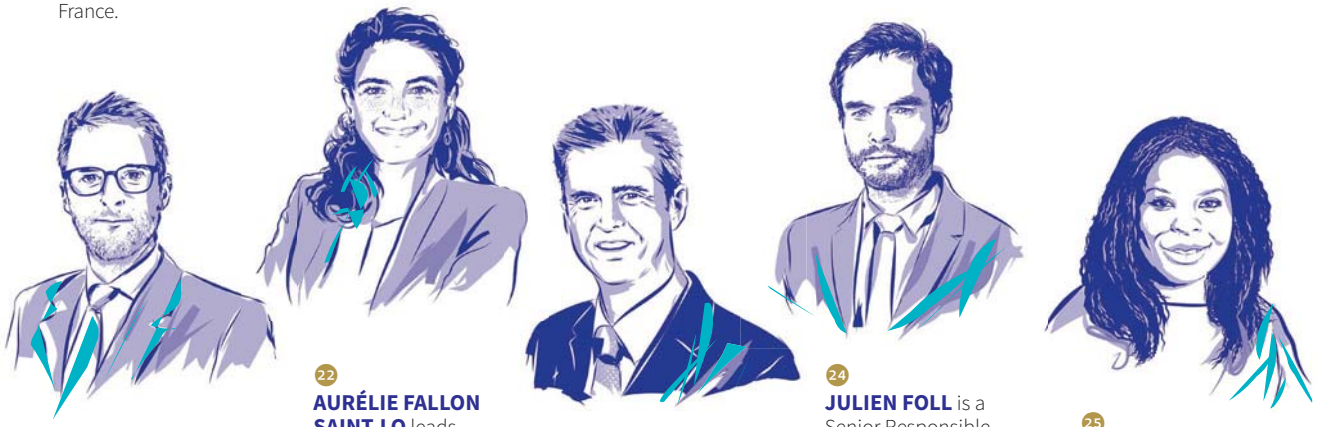
16
DR. ADELINE LOYAU
is a behavioral ecologist. She is currently Guest Scientist at EcoLab in Toulouse[11]. Her research areas include animal communication, maternal investment and the interaction between hosts, pathogens and the environment. Since 2017, she has been an expert member at the Regional Scientific Council for Natural Heritage in Occitanie in southern France.

17
CÉLINE SOUBRANNE
has worked in communication and Corporate social responsibility (CSR) at AXA for twelve years. She is currently the Group's Chief Corporate Responsibility Officer and a member of the Boards of the UN Principles for Sustainable Insurance (UN PSI) initiative, the EpE think tank and ORSE, a multi-stakeholder organization supporting companies in their CSR strategies.

18
EMILY LANDIS
joined The Nature Conservancy (TNC) in 2014. She currently heads up TNC's coastal wetlands strategy, working with governments, communities and business on conservation management. Before joining TNC, she worked for the Pew Environment Group and Rare, a leading conservation NGO.

19
SUZANNE SCATLIFFE
is Director of Corporate Social Responsibility at AXA XL where she oversees AXA XL's global CSR strategy and reporting. She is a Fellow of the Institute of Corporate Responsibility and Sustainability, and serves as Chair of the Insurance Industry Charitable Foundation United Kingdom's Board of Directors.

20
ADIAS GERBAUD
is Head of Environmental Insurance International at AXA XL. A lawyer by trade, she has over 10 years' experience in environmental insurance and is currently responsible for AXA XL's international environmental insurance offering and portfolio (excluding the United States).



21
CHIP CUNLIFFE
is Director of Sustainable development at AXA XL, where he established and manages the Ocean Risk Initiative, which works to identify innovative insurance and finance solutions to the impacts and implications of ocean-related risk. Over the last 10 years, he managed three major ocean science expeditions focusing on the Arctic.

22
AURÉLIE FALLON SAINT-LO leads AXA XL's environmental insurance business in France and Benelux. An environmental engineer by trade, she has worked with industrial groups before specializing in environmental insurance. She is a member of a working group at the French Insurance Federation (FFA) dedicated to environmental risks.

23
MARK WAY is the head of The Nature Conservancy's (TNC) global coastal risk and resilience team. His work focuses on the use of natural infrastructure, such as coral reefs, mangroves and salt marshes to protect communities against the effects of severe weather and climate change. Prior to joining TNC, he led Swiss Re's sustainability activities in the Americas.

24
JULIEN FOLL is a Senior Responsible Investment Analyst at AXA Investment Managers (AXA IM). An expert on environmental issues, his thematic research and engagement work focuses on biodiversity and natural resources conservation. He leads AXA IM's green, social and sustainability bonds research and is a member of the Green and Social Bond Principles Executive Committee.

25
SHADE DUFFY
is Director of Impact Management at AXA Investment Managers (AXA IM), where she leads the impact management and measurement practice for the AXA Impact Investing (Private Equity) Strategy. She has over 15 years' experience including advising institutional investors on responsible investment and corporate governance issues.

[11] Adeline works closely with Prof. Dirk S. Schmeller on the international mountain research project, GloMEC.

1.

Biodiversity loss: what is at stake?

LEAD ARTICLE

Nature under threat

To assess the urgency of biodiversity loss, we spoke to two leading authorities on biodiversity and climate change: Sir Robert Watson, former Chairman of IPBES, and Dr. René Castro, FAO Assistant Director-General, and asked them how serious the current situation is, and what can be done to protect the natural world.

Sir Robert Watson,
Former Chairman of IPBES

What is the extent of biodiversity loss? How serious is the situation?

Sir Robert Watson It is serious. The rate of loss of species is clearly increasing. It is running at tens to hundreds of times faster than natural evolution. In the 2019 IPBES Global Assessment, we said one million species were at risk of extinction – half of those are plants and animals, half are insects. However, if we start to manage biodiversity – if we start to protect our ecosystems, we can stop most from becoming extinct. That means reducing the drivers behind biodiversity loss: changing land use, overexploitation of resources, climate change, pollution, and the increase in invasive alien species.

How accurate is our data in this area? Do we have clear projections for what is going to happen with biodiversity loss?

Sir R.W. There is a lot of work going on. We know what has happened and how – we know how we have transformed our environment. But what is going to happen in the next fifty years? That is more difficult. We need better models. To have a good projection of the future, we need to know the plausible changes in population, in wealth, in per capita consumption, in new technologies and social values. The question is, do we know enough to act? And the answer is: yes, we do. We should not use lack of knowledge as an excuse.

Are we doing enough to stop biodiversity loss?

Sir R.W. Clearly, we need to do more. We are still changing land use. Deforestation is still occurring in some parts of the world, primarily in the tropics and sub-tropics. Air-borne and land-based pollution are still increasing. We are only making reasonable progress on four of the twenty Aichi targets. On some, we are actually losing ground[12].

[12] The Aichi targets are part of the internationally-agreed Strategic Plan for Biodiversity (2011-2020). There are twenty targets in all, including: integrating biodiversity into national development plans, eliminating harmful subsidies, halving the rate of habitat loss, reducing pollution, safeguarding ecosystems and managing agriculture and marine resources more sustainably. For more information on the Aichi targets, see https://www.cbd.int/sp/targets/. According to the 2019 IPBES global assessment, 'good progress' has been made towards components of four Aichi targets: invasive species prioritized, 10% of marine areas conserved, 17% of terrestrial areas conserved, Nagoya Protocol in force, NBSAPs (National Biodiversity Strategies & Action Plans) developed and updated. Progress has been 'moderate' towards some components of another seven targets. For six targets, progress has been poor against all components. For the remaining three targets, information is not sufficient to allow an accurate assessment. The IPBES assessment states that it is 'likely' that most of the Aichi targets for 2020 will be missed. The Nagoya Protocol is a supplementary agreement to the Convention on Biological Diversity; it provides a legal framework for the fair and equitable sharing of benefits arising from the use of genetic resources.

What is the role of the private sector in this?

Sir R.W. A huge role. Governments can put policies in place, but it is the private sector that produces our food, that produces our energy, that runs our transport systems and controls tourism. Many companies are dependent on biodiversity – the food sector of course, but also aluminium producers or power companies, which are dependent on water for their business. The good news is there are companies out there showing that you can be economically viable, that you can make a profit for your shareholders, and still be sustainable. The private sector needs to take a medium and long-term view. Look at Newfoundland in the 1990s – overfishing was so acute that there had to be a moratorium on Atlantic cod. Twenty years later, the cod stocks are still not back to where they were. It takes time for ecosystems to recover.

You mentioned climate change as a driver of biodiversity loss?

Sir R.W. With climate change, you get an acceleration of the pressure on biodiversity. Dry areas, on average, become drier; wet areas become wetter. But you also get changes in precipitation, leading to floods or droughts, and more extreme weather, such as heatwaves. Many of the coral reefs in the Caribbean have been wrecked in the last two decades by just a few major hurricanes. The fact is, we need to look at climate change and biodiversity together. They cannot be separate issues. Both are environmental issues, but they are more than that – they are both development issues.

What do you mean by development issues?

Sir R.W. They affect food, water, energy, security – they are also economic issues. Losing biodiversity comes at a real economic cost. The poorer populations are affected most by biodiversity loss and by climate change. When we look at these ecosystems – forests, wetlands, grasslands, mangrove swamps – they all play a role in providing food and fibre, in providing water and medicine. They help control our climate. This is not just a matter of losing species – we are also seeing local conflicts as a result of biodiversity loss and climate change.

"The fact is, we need to look at climate change and biodiversity together. They cannot be separate issues. Both are environmental issues, but they are more than that - they are both development issues."

-50%

By 2020, signatories of the Aichi targets have pledged to reduce loss of natural habitats, including forests, by at least half.
Source: Convention on Biological Diversity (Aichi Biodiversity Targets) (2019)

How optimistic are you? You said we can stop biodiversity loss, if we act. But will we?

Sir R.W. We will continue to lose biodiversity and we need to understand the implications. How are we going to adapt to that future loss? How can we manage our agriculture, our energy, our water systems better? We are definitely moving too slowly, but hopefully there is enough common sense to draw back from the cliff edge – to realize that to continue along this path is economically stupid, socially stupid and will not be good at all for any of us – the rich, the middle classes or the low-income populations.

LEAD ARTICLE

Nature under threat

Dr. René Castro, *Assistant Director General at the United Nations Food and Agricultural Organization (FAO)*

As we have increased food production, have we become too reliant on a small number of crops?

Dr. René Castro Definitely, what we eat today is less diverse than what our parents ate. Two thirds of the world rely on just nine plants for their energy and nutrition – that is nine plants out of the thousands available. We see the same trend in fisheries and livestock. The fact is, industrial agriculture is not biodiversity-rich and small farmers – who are, to an extent, the guardians of biodiversity – are under constant challenge. They have limited access to finance or new technologies.

What about climate change? Are we already seeing the effects on agriculture?

Dr. R.C. Climate is making matters worse with droughts and floods, the spread of diseases and pests. We are currently forecasting that climate change will reduce yields in the tropics by 10%-15%, depending on the crop. As a result, some of these countries will go from being net exporters of food to net importers. There is also a correlation between extreme weather, violence and migration. We see it in Central America and Mexico, with people moving towards the United States, for example – we see it between sub-Saharan Africa and Europe, and in Asia, from rural areas to the cities, in China especially. We must scale up our efforts to make sure people can have proper livelihoods in rural areas.

There are still millions of people suffering from hunger, why is that?

Dr. R.C. This is the dilemma we are facing. We have enough food to feed the world. But, on the one hand, 820 million people suffer from under-nourishment and on the other, two billion people have weight and obesity problems. One assumption is that the lack of diversity in our diet is affecting human health. Cases of chronic illness, such as diabetes and heart disease are skyrocketing and that is increasing healthcare costs – in some countries to as much as 4% or 5% of GDP. At the same time, we are still seeing increases in the number of people who are under-nourished. On the second Sustainable Development Goal (SDG) – Zero Hunger – we are not progressing, but actually failing. One thing we can do is stop waste – a third of all the food produced is wasted. We have forgotten the moral dimension: that hunger is a crime.

It seems that we need a more sustainable form of agriculture. What are the right incentives for that?

Dr. R.C. Agricultural extension services – technical advice to farmers – have been reduced substantially. Small farmers depend on these services. We need to restore them. The FAO favors providing consumers with more information, so they know, with certain products, if sustainable farming practices have been used, or sustainable fishing or forestry methods. Maybe this has not been happening yet because the agricultural sector was not fully aware of its impact on biodiversity, and because there was a lack of cooperation with environmentalists. There is an opportunity there for us, as the FAO, to promote more dialogue.

Can we increase food production and protect nature simultaneously?

Dr. R.C. There are over twenty countries that have been able to produce more food and increase forest cover at the same time through increased intensity, new varieties and better management, so, it is do-able[13]. Gene sequencing is a reality now – we are able to isolate genes in crops

[13] The FAO's State of the World's Forests (2016) cites case studies from seven countries (where there is evidence of positive trends in food security and forest cover): Chile, Costa Rica, Gambia, Georgia, Ghana, Tunisia and Vietnam.

"We need the right regulations, deals in place and negotiations – and we also need scientists to keep working and to make sure all the technology available reaches small farmers. The world will need to use all of its abilities – and those abilities are there, we have them."

that are pest-resistant or drought-resistant, and this is becoming cheaper to do. Earlier this year, we agreed our first-ever code of conduct for fertilizer with representatives from the fertilizer industry. That would have been unthinkable twenty, or even ten, years ago. For many years, we ignored the fact that agricultural biodiversity and wild biodiversity were happening in the same landscape. Now we know that we need to coordinate our efforts better and manage these jointly.

Still, there are big challenges ahead.

Dr. R.C. With climate change, there is an amber light flashing. If the climate reaches a point of no return, the impact on biodiversity can only get worse. In some regions, like the tropics, there could be a collapse. How much time do we have? Probably twenty years. We need the right regulations, the right deals in place, and we also need scientists to keep working and to make sure all the technology available reaches small farmers. The world will need to use all of its abilities – and those abilities are there, we have them.

1 million

animal, plant and insect species are at risk of extinction.
Source: IPBES (2019)

3

Just three crops (rice, maize and wheat) and three animal species (cattle, pigs and chickens) account for the majority of the world's food-energy intake.
Source: FAO (2019)

Biodiversity & climate change

Climate change has been identified as one of the main drivers of biodiversity loss. The 2015 Paris Agreement aims to limit warming to 'well below 2°C'. There is no guarantee we will meet that target, but it is clear that tackling climate change will also help protect what the World Wildlife Fund (WWF) calls 'the web of life'.

Biodiversity & climate change

EARTH'S CLIMATE IS CHANGING RAPIDLY

+1°C

Since pre-industrial times, **temperatures** have increased by approximately +1°C.[1]

+20 cm

Over the past century, average **sea levels** have risen by more than 20 centimeters because of global warming.[2]

68.5 million

In 2018, more than 68 million **people** were affected by extreme weather and other climate events.[3]

CRITICAL HABITATS ARE BEING LOST

9%

Nine percent of all **species** – more than 500,000 species in total – have **insufficient habitat** for long-term survival.[4]

-3.6 million

Though the rate of **deforestation** has slowed since the 1990s, we still lost 3.6 million hectares of primary rainforest in 2018 – an area the size of Belgium.[5]

+30%

Ocean acidity has increased by 30% since the start of the industrial revolution – 100 times faster than any increase experienced in the past 20 million years.[6]

THOUSANDS OF BIRDS, ANIMALS AND PLANTS ARE AT RISK

28,000+

Out of just over 105,000 **species** so far assessed, more than 28,000 are **threatened with extinction**.[7]

25%

A quarter of **mammals** are **threatened with extinction** – as well as 40% of amphibians, 14% of birds and 30% of sharks and rays.[8]

81%

Since the 1970s, declines in wetlands have affected 81% of **inland wetlands species** populations, and 36% of coastal and marine species.[9]

Sources:
① *IPCC (2019)* ② *UK Met Office (2015)* ③ *Centre for Research on the Epidemiology of Disasters (CRED) (2018)* ④ *IPBES (2019)* ⑤ *WRI – World Resources Institute (2019)*
⑥ *UN Educational, Scientific and Cultural Organisation (UNESCO) (2019)* ⑦ *IUCN – International Union for the Conservation of Nature (2019)* ⑧ *IUCN (2019)* ⑨ *Ramsar Convention on Wetlands (2018)*

DEBATE

Biodiversity & climate change

For a long time, climate change was regarded as our most pressing environmental concern. However, widespread damage to the Earth's biodiversity and a hotter planet combined are changing the lives of plants and animals in ways we are only just beginning to understand. Professor Colin Prentice from Imperial College London and Dr. Cosima Porteus from the University of Exeter discuss the implications of climate change for biodiversity, and why we need better models to assess risk to life on Earth.

Pr. Colin Prentice,
Imperial College London (United Kingdom)

Dr. Cosima Porteus,
University of Exeter (United Kingdom)

Pr. Colin Prentice The recent IPBES report makes it clear that, among the threats to biodiversity, the number one issue is habitat loss. So far, we have not actually seen all that much climate change impact on biodiversity. What we know is that species – plants, birds, fish and so on – are adapting, which is good news. The biosphere is reacting fast, but it has to, because climate change is happening fast.

Dr. Cosima Porteus I have been studying ocean acidification. Oceans are doing us a huge favor, absorbing carbon and dampening the effects of climate change on earth. But, in the process, the oceans are becoming more acidic, and that affects fish – they lose their sense of smell. For our research, we used end-of-century projections for carbon dioxide (CO_2) in European sea bass. Through an experimental process putting sea bass either in seawater with current levels of carbon dioxide, or those replicated for the end of the century, we found that their sense of smell was reduced by up to half in high carbon dioxide seawater. This is important since fish use their sense of smell to locate food, to avoid predators, to find and choose mates, and larvae use it to find appropriate habitats. For some species, such as salmon, it is used for long-distance migration. This loss of smell is not happening yet – but the message is we have to reduce carbon emissions now.

Pr. C. P. The fact is, humans have made many species extinct. We know for sure from the paleorecord that, with the exception of large mammals, biodiversity has quite extraordinary resilience if you look back to previous periods

of relatively rapid warming. It is often said that in the past, change was much slower, and that now it is much quicker. In fact, when we came out of the last ice age, the process may have been long, but the final warming-up that made the difference was completed in twenty years. The point is, somehow species coped with it. The joker in the pack is that we live in a very different, much more fragmented, landscape. We are not allowing natural biodiversity to be expressed fully – we are putting restrictions on it. We should not be complacent and think that species will naturally migrate through landscapes that look like Iowa, with its corn and soybeans. So, if you ask me, what will happen in the future, exactly, I do not know – it is extremely unclear. For the carbon cycle, our models differ greatly. They are all reasonably well tuned to look at something like the real world today, but, for the future, they go off in different directions. It depends, of course, on the assumptions you make. Our models are not being stretched enough, they are being used to track emissions, but they are not being used to ask 'what if' questions, which would be the most relevant. It is a symptom of silo thinking. There are people who study the past, and people who study the present, and they barely talk to each other. If we are talking about a +4°C scenario, I do not think we know what the world would look like. We may not particularly wish to find out, but the fact is we do not know.

Dr. C. P. We need to know more about how different stresses combine and interact. Ocean acidification is just one stress on fish populations in addition to the increase in sea temperature and the potential drop in oxygen. Warmer temperatures may produce smaller fish because the fish have less energy available for growth. Fish also move to cooler waters – that could impact fish availability. At the moment, 50% of our fish consumption comes from wild stock. The fact is, we will have to rely more on aquaculture for our food in the future. The FAO is predicting that aquaculture will have to double by 2050 to keep up with population growth, but we have a CO_2 problem in aquaculture as well, since where water is recirculated, CO_2 tends to accumulate to much higher levels, up to forty times higher. That can affect growth in fish. We are now working with industry partners to find out how we can mitigate this.

23%

Twenty-three percent of total greenhouse gas emissions from human activities derive from agriculture, forestry and other land use.
Source: IPCC (Climate Change and Land, 2019)

500 $GtCO_2$

Over the past 200 years the oceans have taken up 500 $GtCO_2$[14] from the atmosphere out of 1300 $GtCO_2$ total anthropogenic emissions.
Source: IPCC (Special Report on Carbon dioxide Capture and Storage, 2018)

$1.5 trillion

The world's 'blue economy' is worth an estimated $1.5 trillion – that includes offshore oil and gas, tourism, maritime equipment and activity at ports. More than 250 million people worldwide rely on fishing and aquaculture for their livelihoods.
Source: OECD (estimate for 2010), WorldFish (2019)

[14] Gigatonnes of equivalent carbon dioxide (a simplified way of expressing various greenhouse gas emissions in terms of the carbon dioxide that would have the same global warming effect).

POINTS OF VIEW

Biodiversity & climate change

Forests, especially tropical ones, host a wide diversity of plant and animal species, and store large amounts of carbon taken up from the atmosphere. As a consequence, deforestation has serious impacts for both climate change and biodiversity loss. To better understand the processes at work, we spoke to two researchers studying tropical forests, deforestation and climate change.

Dr. Vincent Gauci, *Birmingham University (United Kingdom)*

We have seen very significant deforestation in recent years to make way for crops such as oil palm or acacia. What is the effect on biodiversity?

Dr. Vincent Gauci The character of the landscape changes dramatically, from many hundreds of different plant species per hectare to maybe one or two. With oil palm, we have also seen proliferation of rats – so there is a whole range of other species coming in. We know there has been a 50% loss in orangutans over the last twenty years due to deforestation and we are down to the last 300 or so Sumatran tigers in the wild. It has a very disruptive effect.

After deforestation, do these landscapes become more susceptible to climate change?

Dr. V.G. Yes – we are moving towards a system that does not have the same level of resilience and is not able to adjust to climate shocks. In south-east Asia, for example, we are talking about wet, carbon-rich ecosystems. They do not ignite, they do not burn. Once the trees are removed and the peat is drained for agriculture to make room for plantations, the peat[15] becomes very dry and it becomes susceptible to fire.

And this releases carbon and adds to climate change

Dr. V.G. Yes – peatlands are enormous stores of carbon. Fires occur every summer in south-east Asia. In 2015, during the last big El Niño event, there were huge fires across tracts of land in Sumatra and elsewhere. There is also carbon release just through drainage. When trees are cut down, channels are cut into the peat to drain the land, resulting in an upper meter or so of peat that is then exposed to oxygen, while it has not been exposed for thousands of years. Carbon and oxygen produce aerobic decomposition – when organic materials decompose in the presence of oxygen, and carbon rapidly disappears into the atmosphere as CO_2.

How does deforestation affect the land?

Dr. V.G. It can create artificial boundaries. The hydrology of peatland is such that, if a portion is drained, it will have knock-on effects many hundreds of meters or even kilometers away. This is not unknown to local land managers

[15] Organic deposit which consists of semi-decomposed plant material mixed with varying amounts of mineral, or inorganic, matter (Source: IUCN, 2014).

who will do their best to limit hydrology loss. The management of water in these landscapes is quite a challenge as water can be lost very quickly. Deforestation might also cause encroachment – for example, tigers moving out and seeking food elsewhere, leading to the additional challenge of human-species interaction.

Around the world, the scale of deforestation has been enormous. Do you see attitudes changing?

Dr. V.G. The Amazon is being depleted at the rate of a football pitch of tropical forest every minute. This is very politically sensitive. In Brazil, some land users now feel they can deforest again because of the recent change of government. Elsewhere, in south-east Asia for example, there are moratoriums in place – ironically, some of the big landholders end up almost 'policing' the fragments of natural forest that remain. It is a very complex situation and tensions arise. For example If you build a road, for economic development so that a community can get greater access to markets, more people will come into the forest that the road cuts through; they may lay claim to the land through legal or illegal means with often little policing or resistance, and clear the forest for crops or other products. The challenge is really about people, their movement and livelihoods and balancing the needs for economic development with protection of the forest. And this crosses borders – commodities grown in tropical forests are part of international markets – with palm oil and paper, and so on.

What are the possible solutions? How do we protect these forests?

Dr. V.G. There are efforts to reforest – that can be a solution. In Indonesia, after the 2015 fires, landholders were told to raise the water table in peatland to within forty centimeters of the surface. That provides an opportunity to go back to native tree species that do not grow as quickly, but that grow well in a high-water table environment. It is not easy to raise the water table, but it can be done by introducing dams and sluices and regulating flows through drainage canals. There are a lot of issues relating to this, but landholders are starting to realize that their long-term economic sustainability depends on not losing their peat.

"We are moving towards a system that does not have the same level of resilience and that is not able to adjust to climate shocks."

42%

More than forty percent of soil carbon is stored in the world's peatlands.
Source: IUCN (2019)

POINTS OF VIEW

Biodiversity & climate change

Dr. Diego Navarrete,
The Nature Conservancy (Colombia)

How seriously are governments taking deforestation?

Dr. Diego Navarrete Countries have been taking action. The Paris Agreement commits them to reducing their emissions. In the case of Brazil and Colombia, that means correctly managing agriculture and forestry and coming up with alternatives to reduce deforestation.
In Colombia, 62% of total emissions come from deforestation and traditional agriculture – basically, cattle ranching. For tropical countries, with natural forests, this is a big issue.
The REDD+ program[16] provides a framework for developing initiatives as well as monitoring and reporting progress. In Colombia, the government has been implementing laws and incentives to meet its climate commitments and is working with different sectors and there is now a carbon tax[17].
In Brazil, the context is far more challenging.

How delicate are these forest ecosystems?

Dr. D.N. They are very interconnected. We have fragmented the forest, which has a negative impact on processes such as pollination and seed dispersal. When a forest is cut down, the bridges that connect the different ecosystems within the forest are taken out. Before deforestation, species used to move from the Andean forest to regions in the Amazon. Now, those bridges have been removed and species in the Andes have become isolated from those in the Amazon.

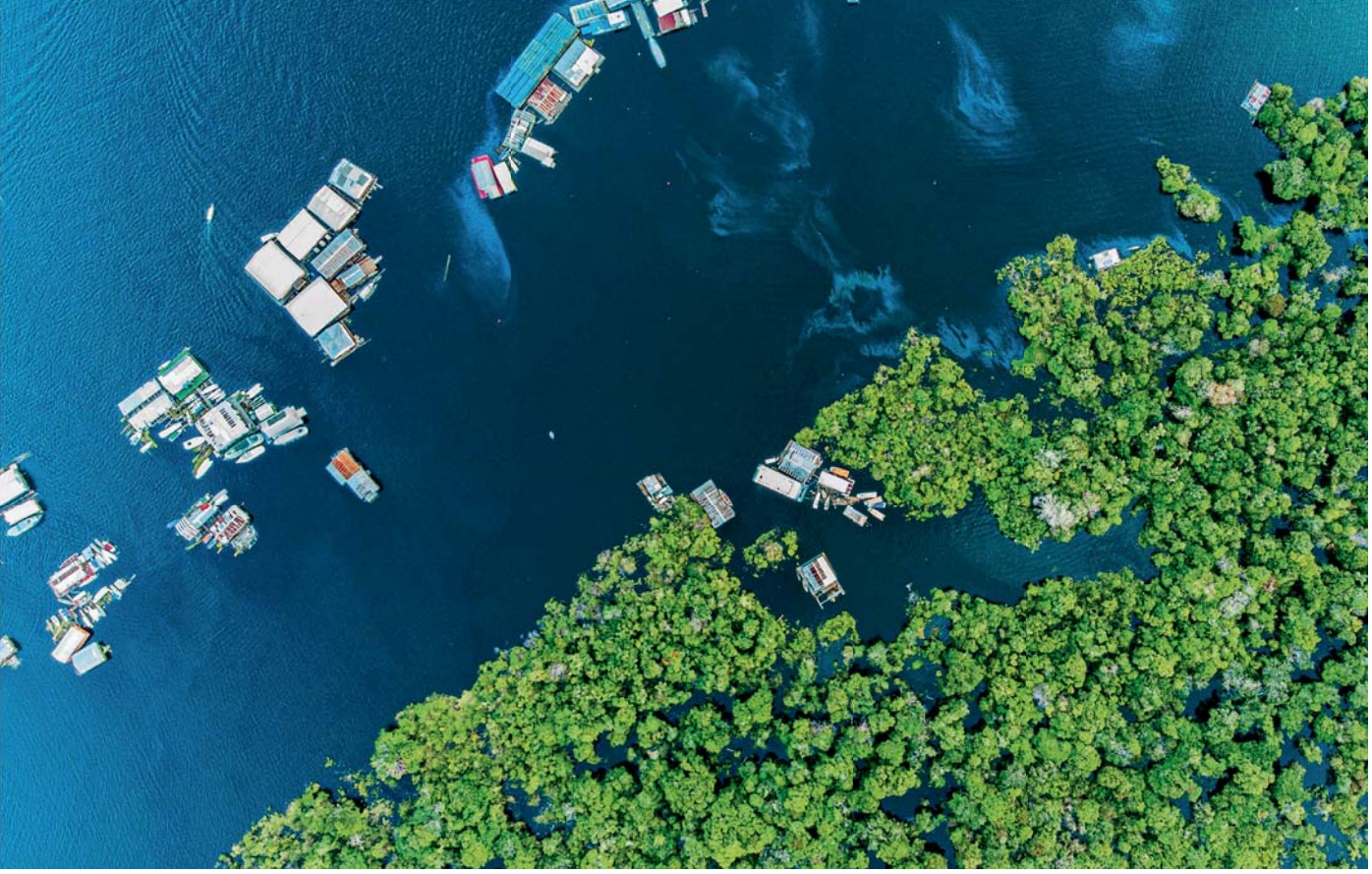
How resilient are species to this kind of change?

Dr. D.N. Some are more resilient than others. Birds, for example, can fly and find resources elsewhere – food, breeding partners, places to nest. But other species are not so fortunate. We often take a very 'human' point of view. We ask: is this species useful to me? The sloth is a great example. Sloths do not represent anything economically, but they are important in ensuring a stable ecosystem.
All species – animals, plants, even human beings – have a role to play. In that respect, if one species is lost, the whole stability of the ecosystem starts to weaken.

How do we improve land management? Can we make it more sustainable?

Dr. D.N. We know that, through deforestation, we release carbon. First, when people cut down and burn the forest. Then, over maybe twenty years, we have legacy fluxes as carbon is released more slowly. If we start to manage land sustainably we can reduce these emissions, even neutralize them altogether – that means moving to lower-intensity agriculture. In Colombia, a program has been developed to convert traditional cattle ranches – pastures where the soil is often degraded – into much more productive, healthier areas through planting trees and taking a more 'silvopastoral' approach, combining trees and grazing land. The result should be better carbon capture, improved biodiversity – and increased productivity.

[16] REDD – Reduce Emissions from Deforestation & Forest Degradation – was first negotiated in 2005 under the auspices of the UN Framework Convention on Climate Change (UNFCCC). It is supported by the UN, World Bank and national governments.
[17] Introduced in 2017, Colombia's carbon tax is levied at $5 /tonne of CO_2. Proceeds are used to finance conservation initiatives. Colombia also applies tax breaks in areas such as renewable energy (source: Conservation Finance Network).



Is business getting involved in helping tackle deforestation?

Dr. D.N. Some companies are involved – they are definitely interested in improving conditions. At TNC, for example, we have a Water Funds Initiative to improve water quality and availability. This initiative brings together the private sector, government, local communities and NGOs, and we work as a solid block. With work on degraded land, there will never be the same level of biodiversity as there is in a forest, even in an area which is managed sustainably. The first step is to stop cutting down the forest – then to concentrate on degraded areas where the soil and vegetation can be improved. With that, quite soon, biodiversity will improve.

15%

Deforestation and forest degradation are responsible for approximately 15% of global greenhouse gas emissions.
Source: Forest Carbon Partnership Facility (2019)

+84%

Satellite data shows an 84% increase in the number of fires in Brazil's Amazon rainforest.
Source: INPE (National Institute for Space Research, based on data for January- August 2019)

"We are moving towards a system that does not have the same level of resilience and that is not able to adjust to climate shocks."

Biodiversity & security

Biodiversity loss has clear implications for our security, with some regions already in conflict over dwindling resources. As a result, we have seen increased migration of nearly 50% over the past two decades[18]. There are also risks to our food production and our health: 40% of the world's population lack access to clean drinking water. The challenge of biodiversity preservation is also a challenge of shared resources and peace.

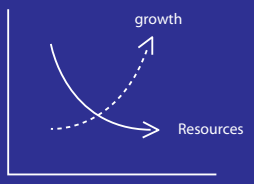
[18] Source: UN International Migration Report, 2017.

Biodiversity & security

POPULATIONS ARE GROWING FAST

x2

Over the past fifty years, the **world's population** has doubled. At the same time, the global economy has grown four-fold and international trade ten-fold, driving up demand for energy and materials.①



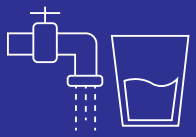
47

least developed countries are among the world's fastest growing, putting pressure on already strained resources.②

60%

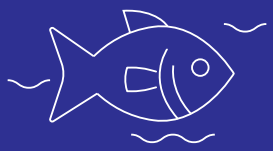
By 2050, to meet rising demand as a result of population growth, **global food production** will have to increase by an estimated 60%.③

NATURAL RESOURCES ARE DWINDLING



40%

40% of the global population **lack access to clean, safe drinking water** – a key 'ecosystem service'.④



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As of 2015, over 33% of world fish stocks were being **fished at unsustainable levels**.⑤

30%

An estimated 20%-30% of the world's **land is degraded** – much of it by crop production, livestock and other forms of agriculture.⑥

THERE ARE RISKS FOR HEALTH, FOOD AND SECURITY

80%

Biodiversity loss is undermining progress towards 80% of the SDG targets related to poverty, hunger, health, water, cities, climate, oceans and land.⑦

821 million

Today, over 820 million **people still suffer** from **chronic hunger**.⑧

40%

40% of all **conflicts** within states in the last 60 years can be linked directly to natural resources.⑨

Sources:
① *IPBES (2019)* ② *Key findings from World Population Prospects (2019)* ③ *FAO (2017)*
④ *IPBES (2019)* ⑤ *FAO (2019)* ⑥ *IPBES (2019)* ⑦ *FAO (2019)* ⑧ *IUCN (2019)* ⑨ *IPBES (2019)*

POINTS OF VIEW

Biodiversity & security

Biodiversity decline is not just an environmental issue. It has much wider implications, particularly when combined with population growth. By the middle of this century, there will be a projected ten billion people[19] on Earth. This means increased pressure on natural resources such as food and water, an increase in risks to human health, and higher levels of migration as people seek healthier, more prosperous lives elsewhere. Researcher and author Dr. Jean-Michel Valantin and IRRI researcher Professor Rod Wing speak about biodiversity loss, the risks for humanity and the need to shift to more sustainable food production.

Dr. Jean-Michel Valantin,
Researcher and author,
The Red Team Analysis Society

In terms of food production, where do you see the main threats to our agricultural systems?

Dr. Jean-Michel Valantin The main pressure today on agriculture comes from a combination of factors: climate change, population growth and pollution, all putting pressure on the soil. Our soil is getting poorer while it contains 80% of the biodiversity on land. For the moment, crops are still growing but what will happen when the soil becomes too dry or too poor because of rising temperatures and more extreme weather? Furthermore, there are cascade effects between the land and sea biodiversity pressures. For example, the American Midwest has seen historic flooding this year. As a result, nutrients from fertilizers wash into the Gulf of Mexico where they cause algal blooms that absorb oxygen and create a 'dead zone', that is to say an area where the level of oxygen has become so low, because of excessive nutrient pollution, that it cannot support marine life such as plankton or fish anymore. However, climate related pressures take place everywhere, not just the Midwest. We had a severe drought in 2018 in Australia; and there have also been heatwaves in recent years in Europe and in the United States.

Could this affect food production and food security?

Dr. J.-M. V. Yes, this can result in food production issues, in higher prices and, ultimately, social unrest. In 2011, some Arab countries saw a spike in bread prices as a result of poor harvests following the heatwaves in Russia and Ukraine. That triggered the 'Arab Spring'. In Tunisia, the very first demonstration was about bread and the same thing happened in Syria. There is a clear connection between food prices and social stability. Can you imagine if this happened in China, a country of 1.4 billion people? Given the size of the country, food tensions could be enough to trigger global effects.

Overall, is there evidence that natural resources are becoming scarcer?

Dr. J.-M. V. Around the world, we are seeing more competition for resources. Fishing fleets in the South China sea are being militarized. Resources are under pressure because of overfishing, pollution, acidification, the proliferation of dead zones. There are more people in the region competing for diminishing resources. For example, in the early 2000's, Somalia was torn apart by civil war and drought, the state collapsed, trawlers came in to Somali waters from countries like Egypt, Iran and Spain and overfished, and Somali fishermen saw their own resources disappearing, so they bought weapons and attacked the trawlers. Because of scarcity, Somali fishermen became Somali pirates. Ship owners were forced to hire private security, an international military task force was created, insurance became very expensive and the cost of crossing the Gulf of Aden spiked.

Have we seen much reaction from governments to this shortage of natural resources?

Dr. J.-M. V. One example is what happened in 2005 after a heatwave in southern China that seriously affected rice production. The Chinese government became

[19] Wold Population Prospects 2019: Highlights, United-Nations, Department of Economic and Social Affairs, 2019.

more aware of food security. Part of their response has been to buy or rent arable land all over the world – in Argentina, for example. That could create new kinds of international tensions. We live in very interconnected societies, which can make us more vulnerable to environmental challenges.

Pr. Rod Wing,
International Rice Research Institute (Philippines)

We are witnessing increased pressure on food supplies – is that a result of population growth?

Pr. Rod Wing Our planet will have 2.5 to 3 billion additional people by 2050. That is a massive increase. As a consequence, we need to learn how to grow higher-yielding crops on more marginal land. Rice is one of the world's most important food crops, if not the most important: it feeds the poorest of the poor. One of the most significant challenges of our lifetime has become to feed our world without destroying our environment. The fact is, we have to grow these crops sustainably. In the case of rice production, one course of action is to build the next generation of supercrops – 'green super rice' – basically, rice that can be grown with less water, less pesticide use, with higher yields and a lower environmental footprint. What is not widely known is that rice is a major contributor to methane emissions, a powerful greenhouse gas contributing to climate change, which makes the need for this green supercrop even more urgent.

What is the role of research? Can we find a technical solution?

Pr. R.W. At IRRI, we are working on gene sequencing, and isolating the 'sustainable' genes – the genes that make wild rice more resilient, better able to withstand heat or drought, for example. The idea would be to transfer these genes into cultivated rice. There are only two types of cultivated rice: the first was cultivated in China 10,000 years ago, the second, separately, in Africa, 7,000 years later. One wild species we are working with is Oryza coarctata, which can grow in salt water. Given rising sea levels, we are now trying to understand more about this species' salt-loving genes. Ultimately, this will allow us to add more genetic diversity to the mega varieties that are grown around the world. Another option would be to domesticate Oryza coarctata, and to bring it into managed production.

There are millions of rice farmers around the world – what can they do?

Pr. R.W. Most rice farmers are small-scale. About 80% of farmers worldwide sustain themselves and grow just enough food to survive. Not all farming practices and technologies are accessible to them although yields can be increased just by laser-levelling a field[21]. It is simple, but not all farmers have access to this technology, which takes a lot of training, education and outreach. That is also one of IRRI's missions. We are building up gene banks with a total of around 700,000 types, or 'accessions', of Oryza sativa – the Asian cultivated rice – in China, India and at IRRI in the Philippines. We want to build IRRI's digital gene bank so we can use the information to accelerate breeding of more resilient, more sustainable varieties.

+49%

In 2017, there were 258 million migrants worldwide, up from 173 million in 2000[20]. According to the latest figures, refugees and asylum seekers make up just over 10% of all migrants.
Source: UN International Migration Report, 2017

30%

Marine resources in the South China Sea have been fished down to between 5% and 30% compared with 1950s levels.
Source: University of British Columbia (Boom or Bust – The Future of Fish in the South China Sea), 2015

3.5 billion

Rice is an essential component of the diets and livelihoods of over 3.5 billion people.
Source: Nature Reviews Genetics: The rice genome revolution: from an ancient grain to Green Super Rice (Rod A. Wing, Michael D. Purugganan and Qifa Zhang), 2018

[20] Figures include all international migrants (those currently living outside their country of birth), including refugees, asylum seekers, economic migrants etc.
[21] Laser land levelling is used to level fields by removing soil from high points of a field and depositing it at low points. The technology enables crops to mature uniformly, improves yields and reduces greenhouse gas emissions by saving energy, reducing cultivation time and increasing efficiency of fertilizer use.

POINTS OF VIEW

Biodiversity & security

To further understand what is at stake in terms of biodiversity, security and potential solutions, we spoke to researchers working on the decline of pollinator populations, the impact of legacy pollutants from mining, and the over-use of fertilizers on our farms.

Dr. Coline Jaworski,
Aix-Marseille University (France)

We are seeing a significant decline in populations of bees and other pollinators. What is happening?

Dr. Coline Jaworski It varies by species and by location. In Europe, one type of bee – the bumble bee – is doing very well overall, while the decline in bee populations in the United States is more serious. There are already noticeable effects on crop production which may be due to a combination of factors: more intensive farming practices, including the use of pesticides, climate change, or the fragmentation of habitats.

Is climate change an important factor?

Dr. C.J. Climate change means plants will flower at different times, and that disrupts pollinators. It also means drier conditions, which leads to fewer plants and flowers. If plants are stressed, they produce less pollen and less nectar, which, in turn, means less food for pollinators. It also affects the color, size and scent of flowers. When looking for food, pollinators rely on floral scent. Recent research shows that when there is too much ozone, which happens often in the south of France, for example, pollinators cannot smell flowers properly anymore and are completely lost.

How resilient are pollinator populations? Can they adapt to these changes?

Dr. C.J. Adapting to a change in floral scent may happen quite quickly, a matter of weeks. For a species to change geographical distribution takes much more time – years or decades. Some species will not be able to do this – they have very restricted areas: if a pollinator is dependent on a specific plant species, and this plant species does not move, then a pollinator cannot follow. They are stuck in a particular area – these are the pollinators the most at risk of extinction.

What happens if we do not tackle this problem?

Dr. C.J. It is very location dependent. Some regions become unsuitable for agriculture because of a combination of climate change, the degradation of our ecosystems and biodiversity decline. Other regions might do well in terms of crop production, but incur other problems such as encouraging invasive species, especially pests.

This has serious implications for crop production…

Dr. C.J. In the United States, we have seen crop yields go down. Apple and strawberry production now relies on farmers moving in bee hives. This is not yet the case in Europe. However, moving bees is not a sustainable solution since we have seen bee hives collapse because of disease linked to being moved. To limit the decline in pollinator numbers, we need to protect natural ecosystems – there is no other way around it. Interestingly, there are studies showing that pollinator populations are healthier in European cities than in the surrounding countryside. There are more flowers

in cities, in private gardens and so on. In agricultural areas, some flowers have been wiped out, with smaller field margins and fewer wild habitats and forest areas. Most European cities have adopted pesticide-free zones, and we know pesticides can have a dramatic effect on insects. We need to reintroduce more flowers into the countryside in terms of both quality and diversity. Flowers are needed all year long and need to be diverse enough to support a variety of pollinator populations.

… and farmers need to consider changing their practices.

Dr. C.J. Farmers are more aware now of the risks of pesticide use. One option is to allow more weeds; many weeds are flowering plants. It is not easy and it may mean a decline in yields because there is competition between crops and weeds. We also need strong scientific arguments to make the case as well as modelling and quantifying to show how much more sustainable this would be over the long term. Providing financial incentives to farmers to encourage them to maintain sustainable, healthy lands is another possibility.

Dr. Sophia Hansson,
University of Toulouse (France)

You have studied pollutants from historic mining sites – it seems that many pollutants remain hundreds of years after mines have closed.

Dr. Sophia Hansson These are mainly heavy metals like lead and mercury – more often than not a by-product of mining. With gold mining, mercury is added to help purify the gold, which means a lot of mercury is released in the areas around these sites. It is a technique that has been around for a very long time; it is efficient, but it is also highly dangerous since it releases a lot of mercury into the environment. Recent work in Sweden showed that concentrations of mercury in the lake and the sediment increased almost a thousand-fold during the time the mine was in operation. Centuries later, this concentration has still not returned to its natural background level.

1,220 tonnes
Artisanal and other small-scale mining released more than 1,200 tonnes of mercury into terrestrial and freshwater environments in 2015. *Source: UN Environment Programme (Global Mercury Assessment, 2018)*

75%
More than three-quarters of global food crop types depend on pollinators, including fruit and vegetables and important cash crops like coffee, cocoa and almonds. *Source: IPBES (2019)*

And these elements remain in the environment?

Dr. S.H. The problem with lead and mercury is that they do not degrade. On a site that was active 500 years ago, lead is still just as toxic today. In fact, in the case of mercury, it can become more dangerous over time as mercury may become methylmercury[22], which is very toxic. It can enter the bloodstream and from there get into the muscles, the brain and the nervous system, potentially causing a serious threat to health.

How do these pollutants end up in the water supply or the food chain?

Dr. S.H. At mine sites, waste – rocks and tailings – erodes and the metals then slowly leach into the soil, then into the groundwater, and eventually reach lakes, rivers and, potentially, the ocean. The main exposure then occurs through drinking water and food products – fish and other seafood. Climate change increases the risks. In mountainous environments, for instance, very dry spells dry up the soil, which starts to crack and becomes less stable, especially if there is also less vegetation to hold the soil in place. When the rain finally comes, the soil may be flushed away from the mountain slopes, bringing old pollutants with it, and potentially affecting villages downstream from the original mine site. In 2013, in the Pyrenees, a mountain range extending along the border between France and Spain, a lot of material was

[22] Methylmercury is formed from inorganic mercury through the action of bacteria and other microbes in various environments, including lakes, rivers, wetlands, sediments, soil etc. If consumed in sufficient quantities, methylmercury has serious consequences for human health, particularly among children and pregnant women.

Biodiversity & security

washed into the streams and rivers – too much, too quickly. It knocked out water supply to nearby villages because the water could not be cleaned quickly enough. The Pyrenees is an area where there is no industry today and you would think it should be pristine, but the majority of lead in the fish from the Pyrenees lakes comes from old mining activities – even though those mines closed down over a hundred years ago. It is still fine to eat the fish – we are not seeing dangerously high concentrations – but it is important that we understand how long these contaminants have been in the system. We have mine sites in the Pyrenees that go back a thousand years and we still see the impact in fish today.

What lessons are there for modern mining? Are we still putting these pollutants into the environment?

Dr. S.H. We have more environmental regulations in place. Therefore, although the mining is occurring on a much larger scale, the environmental impact is smaller. Bigger mining companies – those that are well established and have sufficient funding – tend to follow the rules. Of more concern are the smaller mines, such as some of the artisanal mining that is occurring in South America and Africa, which are often illegal, and where there are no environmental controls at all. There, the pollution can be quite serious. Even if there is a small spill, it will stay – these metals will not just go away. The work we are doing on both old and modern mines shows the importance of regulations.

What is the scale of the problem? Humankind has a long history of mining.

Dr. S.H. It does. In Sweden and Greenland, you can still find lead from old Roman-era mining activities: metals were released into the air and travelled around the world. When it comes to legacy pollutants, the problem is that we do not know how much we are talking about overall. We performed a rough calculation and estimated that, for just the French side of the Pyrenees, there are at least 600 tonnes of lead stored in the soil. The first step is to build a risk assessment map: what stocks we are talking about, how mobile they are, how far into the food chain they have moved and what risks that entails for humans. The knowledge we develop for the Pyrenees can then be applied to historic mine sites elsewhere.

Pr. Graeme Nicol,
Ecole Centrale de Lyon (France)

Over the years, we have dramatically increased our use of fertilizers. How is this changing our soils and our environment?

Pr. Graeme Nicol If you look at the figures, we are now adding more nitrogen to the soil through artificial fertilizer than is added through natural processes. In effect, we are doubling the input of what is called reactive nitrogen into the world's soil – which is really quite extraordinary. We are not necessarily changing the nitrogen cycle, in terms of its chemistry – we are accelerating it. Because we are putting in a lot more ammonia through fertilizer use, we are producing a lot more nitrous oxide, which is a greenhouse gas. Since pre-industrial times, the concentration of nitrous oxide in the atmosphere has gone up by nearly 20%, and that is due to human activity.

What about the world around us – biodiversity? What is the impact from these fertilizers?

Pr. G.N. When you add ammonium to the soil, more than half usually gets converted to nitrate. Plants can take up nitrate of course, but the problem is that nitrate has a negative charge and so does soil, so there is no electrostatic mechanism for it to remain in the soil, which means it is easily washed out. The result is nitrate pollution. You have run-off into waterways and coastal areas. And where you have high rates of nitrogen, you get eutrophication

– unnatural or atypical blooms of growth, like algal blooms. When this organic matter sinks and dies off you encourage other bacteria, which use up oxygen that reduces oxygen levels and that is when fish and other marine animals start dying.

How do we combat this? Can we reduce fertilizer use?

Pr. G.N. It is not necessarily the use of fertilizers, per se, that is the problem. It is how we apply them. If you put in a large amount of fertilizer, such as ammonium nitrate or urea, bacteria react and produce nitrous oxide, and that is the problem. You could use a slow-release fertilizer – the longer it is retained in the soil, the more the plants will take up and the higher your nitrogen-use efficiency. Basically, we are trying to stop the bacteria having a big party. The other option is to use a standard fertilizer and apply a chemical compound that inhibits the bacteria, but that is not the most natural solution.

Are there other possibilities?

Pr. G.N. We have BNI – biological nitrification inhibition. Some plants produce inhibitors naturally. These inhibit bacteria – to give themselves a better chance of taking up the ammonia that is produced from decay and mineralisation. People have been trying to promote the use of BNI. Currently, a lot of commercial breeding strategies assume high levels of fertilizer use, but in certain systems – in pasture for grazing animals for example – you can get grasses that have a much higher BNI activity, so when sheep and cows excrete you can slow the process. There are also *archaea*[23] in the soil, which we have known about since 2005. We have shown that these *archaea* also oxidize ammonia, but in doing so they produce half the amount of nitrous oxide. The trouble is, when you add ammonium fertilizer, the *archaea* do not really use it, it is the bacteria that use it. So, if you are using a slow-release fertilizer, what you are doing, in effect, is preferentially selecting for the *archaea* – the bacteria will be outcompeted because bacteria need higher concentrations.

How do we apply this practically?

Pr. G.N. We know that currently, 35% of all nitrous oxide emissions come from agricultural systems and that is what we need to control. In Europe, we have the EU Water Framework Directive, which is in place to control nitrate levels in water, as nitrate is toxic at certain levels. There are nitrate-vulnerable zones where there are restrictions on fertilizer use. If we can increase our knowledge of the micro-biology present in a particular soil – soils will vary from place to place – then you can decide which fertilizers to use, and when.

200 million

Fertilizer use worldwide now exceeds 200 million tonnes – a more than seven-fold increase since 1960.
Sources: FAO and International Food Policy Research Institute, 2020

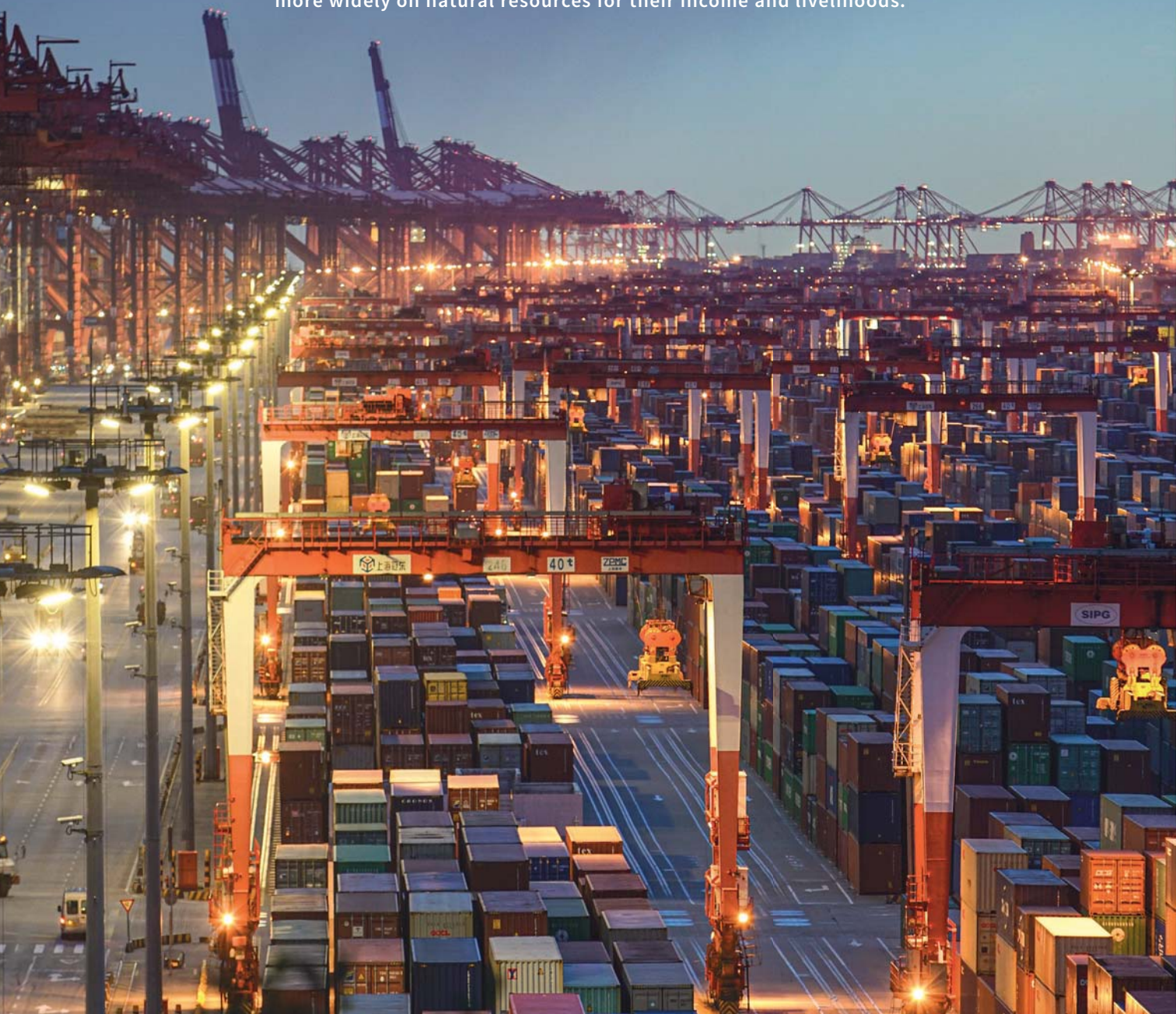
Note on Nitrogen Cycle

Nitrogen forms the basis for compounds essential to living organisms *(air contains just over 78% nitrogen)*. **Bacteria in soil and in the roots of leguminous plants convert atmospheric nitrogen** *(N_2)* **to ammonia** *(NH_3)*; **this process is known as nitrogen fixation. Nitrogen is then taken up by plants; animals consume these plants and return the nitrogen to the soil through their excreta and when they die; in the soil, the ammonia is converted first to nitrite** *(NO_2)*, **then to nitrate** *(NO_3) (nitrification)*, **before being converted back into molecular nitrogen in the atmosphere** *(denitrification)*. **Nitrous oxide is produced as part of this denitrification. Reactive nitrogen refers to nitrogen compounds transformed in the cycle; they include compounds that support plant growth** *(ammonia, nitrate)*.

[23] *Archaea* are microorganisms similar to bacteria in size, but radically different in molecular organization.

Biodiversity & the economy

Biodiversity loss will come at a cost for our economies. Habitat loss, pollution, the rise in pests and other invasive species will affect sectors from agriculture, fisheries and forestry to real estate development, tourism and public health. These costs could run into billions of euros. Most at risk will be low-income populations, which rely more widely on natural resources for their income and livelihoods.

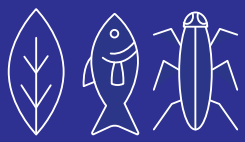


Biodiversity & the economy

BIODIVERSITY LOSS WILL COME AT AN ECONOMIC COST

$140 trillion

The **world's ecosystems** provide **benefits** worth an estimated $125 to $140 trillion a year – equivalent to more than one-and-a half times global GDP.①



$540 billion

If the increase in **invasive species and pathogens** is not stopped, the **cost to world agriculture** could be as high as $540 billion a year.②

6%-14%

By 2050, countries in the Middle-East and North Africa region may have **lost** between 6% and 14% of their **GDP** due to water scarcity.③

LOW INCOME COMMUNITIES WILL SUFFER MOST

47%

Low income countries **depend on natural capital[24] for almost half their wealth,** compared with just 3% for OECD countries.④

78%

Seventy-eight percent of the **world's extreme poor live** in rural areas, and **depend on ecosystems** and the goods they produce for their livelihoods.⑤

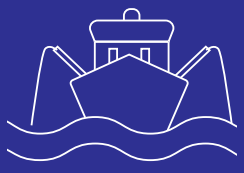
33%

International trade shifts the environmental impact of economic output from developed to developing countries. In Central and South America, 33% of **biodiversity impacts** are **driven by consumption** in other regions; in Africa, that figure is 26%.⑥

AGRICULTURE, FISHING AND TOURISM ARE AT RISK

150

Approximately 150 **livestock breeds** became **extinct** between 2000 and 2018.⑦



97%

Ninety-seven percent of **fishermen live** in developing countries. Globally, the fisheries sector employs an estimated 120 million people.⑧

50%

Australia's Great Barrier Reef has lost half of its coral since 2016 due to warmer ocean temperatures.⑨

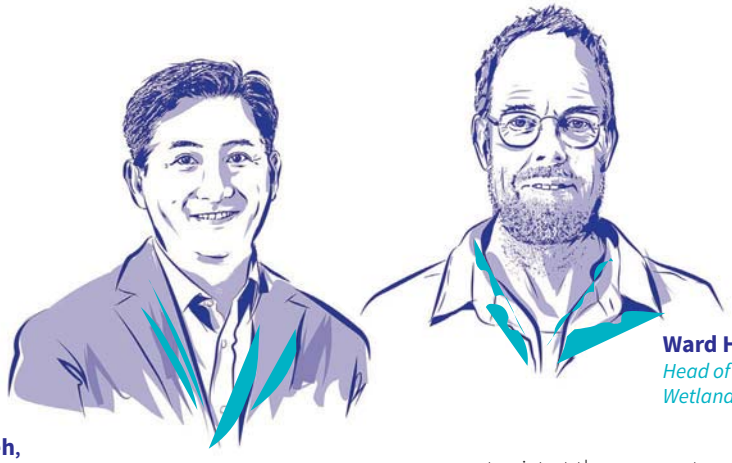
Sources:
① *Organisation for Economic Cooperation & Development (OECD) (2019)* ② *Royal Botanic Gardens, Kew (2017)* ③ *World Bank (2016)*
④ *World Bank (2018)* ⑤ *World Bank (2014)* ⑥ *OECD (2019)* ⑦ *FAO (2019)* ⑧ *WorldFish (2019)* ⑨ *National Geographic (2018)*

[24] Natural capital refers to a country's natural resources – geology, soil, air, water, plants and animals etc.

DEBATE

Biodiversity & the economy

We know that ecosystems provide countless benefits – from food, clean water and climate regulation to habitats for species and protection against natural disasters. The terms 'natural capital' and 'environmental services' were first coined in the 1970s. However, putting a value on these services is difficult. Can we really put a price tag on nature? If we do, will it help us protect ecosystems? And what about the cultural aspects – the sense of belonging and beauty we derive from the natural world? Ward Hagemeijer from Wetlands International and researcher Dr. Kelvin Peh, who specializes in ecosystem services, discuss the possibilities and pitfalls of putting an economic value on natural resources.



Dr. Kelvin Peh,
Southampton University (United Kingdom)

Ward Hagemeijer,
Head of Business and Ecosystems, Wetlands International

Dr. Kelvin Peh There are two types of tools to assess ecosystem services: one is written – basically, a step-by-step guide and very site-specific, the other is based on computer models and used for much larger areas – regional or national. A computer-based model will require specialist skills. The idea behind TESSA[25], the tool I have been involved in developing, is that it provides a very simple cost-benefit analysis: it compares the ecosystem with alternative 'states', such as the building of a hotel. TESSA is designed for non-experts and local communities are involved throughout the process. Their involvement is crucial and, often, they are the ones producing the data.

Ward Hagemeijer Development decisions are made along economic lines and it is hard to be heard without using economic terms. We may want to look for a measure that is not so biased towards economic value but that does not exist at the moment, and putting a fair value on these ecosystems is very complex. My research concerns the conservation and restoration of wetlands. People and nature depend on wetlands for their survival – they underpin so many of the UN Sustainable Development Goals and store a lot of water and carbon. However, there have been very significant losses, with some estimates going up to as much as 75% of wetlands lost or degraded. A wetland itself has value, but it only exists because it is connected to the world around it – it is part of the water infrastructure and it may be on migratory routes for birds. Its value may also be cultural, intrinsic. It is difficult to put a value on the survival of a species for instance, but it makes perfect sense to factor in such a measure.

Dr. K.P. We have been developing TESSA with that goal in mind since 2010. For our second version, we have developed a specific module dedicated to cultural services provided by ecosystems representing sense of place, heritage and other intangibles that require a different methodology. These should be valued qualitatively, rather than

[25] TESSA: Toolkit for Ecosystem Service Site-based Assessment; the toolkit was developed with the support of Birdlife International, the Royal Society for the Protection of Birds (RSPB), Tropical Biology Association, UNEP's World Conservation Monitoring Centre, Anglia Ruskin University, the University of Cambridge and the University of Southampton, as well as the AXA Research Fund.

quantitatively. In terms of data for water and carbon, current tools are reasonably appropriate but with other services, such as pollination, there are still issues, and collecting data on pollination is very hard work. It is sometimes easier to convey the economic argument to governments. This can fight the idea that there is a choice somehow between economic prosperity and environmental protection. With TESSA, the objective is to provide evidence and, instead of relying on ethical or legal considerations, to be able to speak to governments or local communities and say it is in your economic interest to protect this biodiversity or this environment.

W.H. Attitudes have changed. There is more recognition of the value wetlands bring – draining is no longer the automatic response and a lot of work has been done in this respect through the Ramsar Convention[26]. In many places though, there is still no overall vision on how to deal with landscapes that have multiple functions. In most countries, governments' over-riding vision is economic development: they are open to conserving nature and to recognizing ecosystem services as a basis for development, but that is not their starting point. It is often about compensating for damage rather than taking a more strategic approach. Ecosystems can be quite resilient, but if you change a landscape to such an extent that the ecosystems are no longer able to perform their functions, then you will lose many services that the ecosystem was providing. If you look at tar sands mining in Canada, entire square kilometers of the surface were dug up to a depth of several hundred meters, changing the landscape dramatically with no way for the wetlands to be restored. What is frustrating is that the mining could have been done in a different way. If river courses were left in place, for example, or the gradient in the soil systems, then restoration would have been possible. At this point, we are able to provide a green landscape after mining, but that landscape does not provide the same services, functions or biodiversity.

35%

Between 1970 and 2015, 35% of wetlands were lost; wetlands are disappearing three times faster than forests. *Source: Global Wetland Outlook (Ramsar Convention on Wetlands) (2018)*

Dr. K.P. Valuing biodiversity is useful to business as they often depend on ecosystems or have an impact on them. Putting a value on nature could help business identify risk, target their management more effectively, and understand the conflict between different environmental issues. For the insurance industry, once value has been established, it is easier to assess risk and to create a product that will mitigate that risk. These assessments on their own are not enough, of course, and it is important to still bring in the more traditional, intangible arguments. We can identify the costs and benefits but, in protecting biodiversity, an ecosystem services assessment is just one tool, not a magic bullet.

W.H. Assessments happen in a broader context. There is the idea of 'net gain' – a commitment to return the landscape to a better state of repair, in terms of value for nature and people, once a project is finished. There is a responsibility for both regulators and companies. Ideally, regulators are well enough informed to protect ecosystems and allow for effective planning – that is not always the case. Sometimes, within governments, two essential ministries, oil and environment for instance, do not speak to each other. It is the companies' responsibility to use the knowledge they have – or develop that knowledge, if they do not have it – and not just take advantage of low standards. This is also where lenders can make a difference by applying conditions on lending money.

29%

Coastal wetlands can reduce damage from flooding by up to 29%. *Source: TNC (2019)*

30%

An estimated 30% of the world's soil carbon is stored in peatlands, making peatlands a key part of the fight against climate change. *Source: Centre for International Forestry Research (CIFOR) (2018)*

[26] The Convention on Wetlands, called the Ramsar Convention, is the intergovernmental treaty that provides the framework for the conservation and wise use of wetlands and their resources. It was agreed in 1971 in Ramsar, Iran, and came into force in 1975. Nearly 90% of UN member states have signed up to the Convention.

POINTS OF VIEW

Biodiversity & the economy

Our economies depend on natural resources. However, biodiversity has yet to be rigorously and systematically integrated into decision-making. We spoke to three scientists to help shed light on the connection between biodiversity and well-functioning economies, through the example of the proliferation of invasive species and their impact on economic sectors, the benefits of nature on people's health and well-being, and the role of mountain ecosystems in providing fresh water to local communities.

Pr. Franck Courchamp,
University of Paris Sud (France)

Invasive species have been cited as one of the main causes of biodiversity loss – how big a problem is this?

Pr. Franck Courchamp This problem affects every region in the world, and, in addition to the impact on biodiversity and ecosystems, it causes damage to human health and to the economy. Every day, hundreds of species are introduced into areas where they are not native. Of course, not all are invasive. Generally, we reckon about 10% will become established in the new environment. Of those, about 10% will become problematic.

These invasive species are being introduced mainly through trade or tourism. Given the scale of the phenomenon, the total effect is enough to represent a true issue. We are now working to find out what traits make species potentially invasive, and what makes certain ecosystems more resistant, so we can intervene earlier, before a species becomes problematic.

You mention health and the economy – do we have any idea how much invasive species cost us every year?

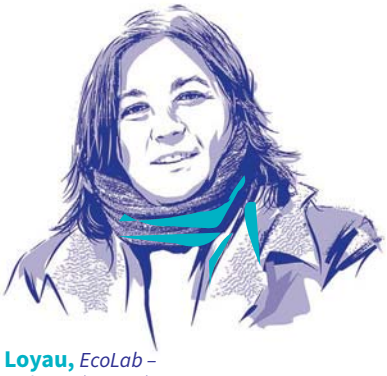
Pr. F.C. There are various effects. We published a study three years ago on the economic costs of invasive insects and we came to an estimate of $70 billion a year. That represents a small part of the real cost. There are many costs that are not accounted for – species that have not been evaluated, and many countries with no data.

How immediate is the impact of these invasive species?

Pr. F.C. The introduction of cats or rats on an island will very quickly kill the native vertebrates, such as birds and lizards, because these species have never been in contact with that particular predator and have not evolved to protect themselves. There are also less immediate effects, for instance invasive plant species that modify the soil composition, or the amount of available water or light. Studies show that, on average, there are fifty years between the establishment of a species and the appearance of impacts from that species. With climate change, species are gradually shifting towards the poles.
The tiger mosquito is a good example: each year it is venturing further north due to warmer winters.

50%

Plants make up half of the invasive species reported as impacting biodiversity for food and agriculture. Insects account for another 16%.
Source: FAO (2019)



Dr. Adeline Loyau, *EcoLab – University of Toulouse (France)*

The tiger mosquito carries possibly thirty different viruses – some of them lethal for humans. The impact may be rapid, but the process of invasion itself is relatively slow.

How can we tackle this problem? You mentioned it was about acting before a species becomes invasive?

Pr. F.C. Generally, it is much cheaper and more efficient to prevent invasions – or at least to react quickly once they happen – than it is to manage already established invasive species.
The Asian hornet, which invaded France in 2004, preys on honeybees. It is now all over France and in neighboring countries, and it seems unstoppable. This invasion appears to have stemmed from just one female hornet hidden on a container ship. Once a species is established, as is the case for the Asian hornet, it is almost impossible to remove. One solution is better biosecurity. In Europe, we have just started using a blacklist of about 50 species, compared with the 14,000 exotic species and hundreds of problematic invasive species we have there. New Zealand has developed a 'white list', which requires proof that a species is not potentially invasive before allowing it into the country. There is a switch in the burden of proof, and that is much more effective. A timber company, for example, should survey the insects present in the wood it trades and make sure the insects are not invasive or are removed before importation. It should not be scientists and NGOs trying to prove that species are problematic or not. Of course, there is resistance because it is costly to have these biosecurity measures and because companies would have to bear the cost. Currently, the cost is on society – on taxpayers. And the cost is much higher because of the damage involved.

Research shows biodiversity improves our sense of well-being. How is that?

Dr. Adeline Loyau Protecting biodiversity is not just about food or clean water, it is also about our well-being, both psychological and physical. This is something that is often overlooked. We already know about the link between stress and our physical health. If we feel good, we are better able to resist viruses. Biodiversity and time spent surrounded by nature have been shown to decrease risk of illnesses like heart disease, obesity, diabetes, asthma – it can even reduce the amount of time you spend in hospital when you are ill.

What is behind this finding? Is this purely psychological?

Dr. A.L. It is not easy to distinguish between the psychological and the physiological. This is quite a new field, so there are many things we cannot yet explain. It may simply be linked to stress reduction. A forest, for example, is quieter, our senses are not under attack, there are fewer electric screens.
We can put some distance between ourselves and our problems – it is a kind of meditation almost. It could also be better air quality in green areas or the physical exercise, if you are walking. There have been studies comparing people walking in the woods and those walking in a city. They show different results: walking in woods reduces stress and improves health more than in the city. Wilson's theory of biophilia suggests that humans are drawn to nature, from an evolutionary viewpoint, because nature provides all our needs[27]. There is also a theory developed in Japan that we breathe in molecules called phytoncides[28] produced by plants and trees, which enter our bloodstream and our brains and influence our sense of well-being and health.

[27] The concept of biophilia was first coined in the 1980s by the American biologist and author Edward Wilson. Biophilia refers to an innate tendency among humans to seek connections with nature and other forms of life.
[28] Phytoncides refer to anti-microbial compounds derived naturally from plants and trees; phytoncides prevent rotting and help plants stave off attacks from insects and animals.

POINTS OF VIEW

Biodiversity & the economy

For the moment, it is just a working theory, but we have detected phytoncides and know they exist.

What about the impact nature has on recovery rates after illness and subsequent health costs?

Dr. A.L. This is difficult to measure in any objective way. There was a study in the 1980s, which really triggered this whole area of research. It looked at two groups of patients at the same hospital with the same nursing staff – they had undergone the same surgery. One group had access to a window, which looked out onto greenery, the other had a window but they looked out at a brick wall. The study showed that the first group recovered more quickly, left the hospital sooner, had to take fewer painkillers, and were less difficult for the nursing staff. The results were not quantified in money terms but this is the kind of thing that can be calculated – for example, we know exactly how much spending a day in hospital costs.

To what extent would you say that the link between well-being and nature is a first world issue?

Dr. A.L. There is no reason to suppose that what happens in rich countries does not also apply to poorer countries, but yes, to put it bluntly, it can be seen as a rich world problem. In developing countries, it is clear that the perception of well-being is not necessarily a top priority. In richer societies, it is only once material well-being is satisfied – enough to eat and decent housing – that people start to realize that the loss of nature may be affecting their health and well-being.

What type of investment are you referring to? More green spaces?

Dr. A.L. It is an idea that is gaining ground, but that is probably to do with the heatwaves we are seeing in Europe. I used to live in Leipzig which is a very green city – the parks are planted with local trees with lots of life in them – squirrels and birds. As a result, you do not feel so caged in. In terms of planning, you see the consequences of decisions taken thirty or fifty years ago. For future planning, this is something to take into account. More people around the world are living in cities than in the country and cities are continuing to expand. This poses the question of the effect on our health. Currently, our politicians and urban planners think about these issues in terms of heat, not in terms of people needing these green spaces psychologically.

Pr. Dirk S. Schmeller,
Institut National Polytechnique, Toulouse (France)

We are seeing very significant changes in mountain ecosystems. What are these changes, and what can we expect to see in the years ahead?

Pr. Dirk S. Schmeller A number of current models underestimate the problem of mountain ecosystem change. It is happening much faster than we thought and we can already see a lot of change in the mountains: much higher variability of temperature and changes in precipitation. Some years, the water level is a meter down, others, it is a meter up; some years, there is snow late in the season and in others there is not much snow at all, and, as the snow melts, there is less water coming down into the lakes.

And that has an impact on freshwater as a lot of our freshwater comes from the mountain…

Pr. D.S. Yes – there is an impact in terms of volume with high variability, which makes it difficult to manage if there are no reservoirs with sufficient capacity. In spring, you may have too much water, in summer, if there is a drought, fields will still dry out. This is a problem of extremes. There is also an issue of quality: if an ecosystem is not working, it is not filtering and cleaning the water as efficiently, and with a system that is out of balance there may be more parasites and pathogens, often from cattle and other livestock. There has been a considerable increase in pressure from livestock. Legacy mining is also an issue in the Pyrenees. In the Taiwanese mountains, the main problem is plastics pollution from the growth in tourism and agriculture. The increase in the world's population has been an important factor. Water consumption in the 18th century was 15-20 liters a person. In 1975, it was 106 liters, and it has now grown to around 140-150 liters. If we want to continue using this volume of water, given the increase in population, it is likely to be very expensive due to the costs of transport, cleaning and storage.

33%

A third of London is set aside for parks and gardens. The figure is much lower in other cities, however. In New York, it is 27%, Paris 9.5%, Tokyo 7.5% and Istanbul just 2.2%.
Source: World Cities Centre Forum (2019)

50%

Mountains provide freshwater for more than half of humanity.
Source: Convention on Biological Diversity (2019)

How resilient are these mountain ecosystems?

Pr. D.S. The issue with mountain ecosystems is that they are less complex than lowlands, with fewer species and they are therefore much more susceptible to the impacts of climate change, with the change itself being more profound. One can also expect species loss due to increasing temperature: species can still move to higher altitudes, but there is a limit. Smaller lakes produce variations in temperature with water heating up much faster and then heavier rainfall cooling it down again that adds stress to the system.

Do you see much adaptation among local communities?

Pr. D.S. Not for the moment or, if any, it is very slow. Around the Toulouse area where I work, there is not much discussion on the need to change water management. Farmers in the foothills had real issues with drought last year, and people may realize it is getting hotter, but they do not realize to what extent this may impact their livelihoods.

What is the role of public decision makers in your opinion?

Pr. D.S. By and large, politicians do not understand that climate change and biodiversity loss are economic issues, with a true opportunity to develop a green economy. They are potentially risking the livelihoods of future generations by not acting to stop climate change and biodiversity loss. Because of the reaction time of ecosystems, what we are experiencing now is the result of what we have been doing over the past 30-40 years, while most politicians work in four or five-year cycles.

2.

Changing the way we do business: AXA and biodiversity loss mitigation

CORPORATE VIEW

Changing the way we do business

Suzanne Scatliffe, *Corporate Social Responsibility Director, AXA XL*

"For a long time, the role of nature in combating climate change has been underestimated by society. That is now starting to shift. It is impossible to adequately tackle climate change without addressing biodiversity and ecosystem loss. Ultimately by conserving nature and restoring ecosystems we reduce vulnerability and increase resilience - the essence of our purpose as an insurer."

Companies are increasingly recognizing the adverse impacts resulting from biodiversity decline, such as risks to their operations and supply chains, as well as liability, regulatory, reputational and financial risks. Biodiversity conservation and restoration can provide opportunities for companies in terms of sustainable business models, cost savings and improved relations with stakeholders.

Private sector involvement is key in the efforts to mitigate biodiversity loss considering the gap in required funds; currently, about $39 billion per year is allocated to conservation while an estimated $300 to $400 billion per year is needed to preserve healthy ecosystems[29]. Conversely, approximately $500 billion per year flow to fossil-fuel and agriculture subsidies[30]. To channel private funds towards biodiversity, different mechanisms exist, such as investments in natural infrastructure and sustainable supply chains, biodiversity offsets, carbon offsets, impact investing or establishing natural capital as an asset class. However, one of the main barriers to scaling up investment for conservation is the present lack of commonly accepted metrics such as those developed for climate change, inconsistent data and tools to measure biodiversity impacts.

In spite of these challenges, AXA has started to build biodiversity into its corporate responsibility strategy as an extension of its climate change pledges. AXA has been a leader on climate change within the financial industry and was the first major insurer to divest from coal in 2015. It has also committed €12 billion to new, green investments by 2020. This has included investments in real assets, private equity and green bonds. On green bonds in particular, AXA has developed a detailed due diligence process and system to ensure the quality of green bond offerings, which has resulted in a line by line assessment of over 400 green bonds.

Our conversation with Céline Soubranne, AXA Group, Suzanne Scatliffe, AXA XL – the Group's Property & Casualty and Speciality Risk division – and Emily Landis, from The Nature Conservancy, outlined the relevance of biodiversity for AXA as a responsible company and its main commitments in this area.

[29] Crédit Suisse AG and McKinsey Center for Business and Environment, Conservation Finance – From Niche to Mainstream: The Building of an Institutional Asset Class, 2016.
[30] OECD (2019), Biodiversity: Finance and the Economic and Business Case for Action, report prepared for the G7 Environment Ministers' Meeting, 5-6 May, 2019.

Why is biodiversity important to AXA?
Beyond the moral argument of preserving biodiversity, its decline has several implications for AXA's business.

In recent years, the stronger intensity of storms, hurricanes, flooding and forest fires, coupled to urbanization, has resulted in more damage and an increase in claims, impacting the Property & Casualty business line of the insurance sector. In 2017 and 2018, the insurance industry paid out nearly $230 billion[31] on natural disasters. We know that ecosystems, such as wetlands and coral reefs, help protect coastal areas against storm damage and flooding. Nature also helps in the fight against climate change itself – by storing carbon, for example, in the case of peatlands. By protecting natural capital, insurers can also protect local communities and businesses and, over time, reduce the impact of natural disaster-related claims. Worldwide, more than half of the current losses from natural disasters are not covered by insurance. This is true of developing countries, where there is no tradition of insurance, but it also often applies to developed countries. In Houston, Texas, 80% of homes were not insured for flood damage in 2017 when parts of the city were devastated by Hurricane Harvey[32] with only 28% of the homes in 'high-risk' areas for flooding.

The decline in the 'natural world' also has implications for our health: the poorer quality and variety of our diets due to the reduction of existing crops and a weaker capacity of natural ecosystems to provide us with fresh air and clean water and the reduced availability of natural resources for our medicine – all have the potential to negatively affect our health with higher ensuing costs for the insurance business.

Furthermore, biodiversity loss is a material issue for the complex supply chains of companies operating in different sectors, such as food, agriculture, retail, luxury or pharmaceuticals.

"**With biodiversity loss, there are true societal concerns. There are also clear connections with AXA's business.** What is happening is a wake-up call. Everyone knows the situation is serious and it is now time to come up with solutions. We need more research and we have to work through both our insurance products and our investments to help companies adapt and make the transition to a more environmentally sustainable future."

Céline Soubranne,
Chief Corporate Responsibility Officer, AXA Group

Turning carbon blue

Carbon credits – tradable permits to emit carbon dioxide – have existed since the 1990s. AXA XL and The Nature Conservancy (TNC) are working on extending the concept to blue carbon and resilience, with the objective of creating a market value for the resilience services provided by coastal wetlands such as salt marshes and mangroves, and driving investment in these ecosystems.
These areas help protect local communities from erosion, flooding and storm surges, and they are also important in the fight against climate change and biodiversity loss. For this initiative, two blue carbon sites have been identified in the United States, the Virginia Coast Reserve in Virginia and Rookery Bay in Florida, as well as a third site in Belize – the atolls off the coast of Belize City. Additionally, talks are underway on a possible fourth site in the Caribbean. While blue carbon sites are chosen on the basis of their environmental importance, government and local community buy-in is also vital.

These 'blue resilience carbon credits' should appeal to investors with a direct interest – hotel groups that want to preserve local areas of natural beauty, or insurance companies that recognize the importance of building resilience. Ideally, with more investment in 'green infrastructure', we can reduce reliance on traditional 'grey infrastructure' such as concrete sea walls. The credits are also tied to the Sustainable Development Goals (SDGs) – specifically, to goal 13 – Climate Action – which calls for greater resilience and adaptive capacity to climate-related hazards and natural disasters.

[31] Swiss Re Institute (Sigma estimates), 2018.
[32] Munich Re: Towards a Flood Resilient Future – A US Perspective (2018). Following Hurricane Harvey in 2017, flood insurance rates in Houston have increased by an estimated 15%-20%.

Emily Landis, *Coastal Wetlands Strategy Lead, The Nature Conservancy*

"Carbon resilience credits are a way of preserving ecosystems for their value to mitigate climate change, protect people and our coastlines. However, coastal wetlands have traditionally received less funding compared with forests for climate mitigation. There is a need to increase investments in restoration and monitoring, including to provide a refuge for the biodiversity that depends on these coastal wetlands. The appeal of blue carbon resilience for companies lies in the fact that they can have traditional carbon offsets, while also investing in natural flood barriers and other co-benefits."

The rarefaction or destruction of natural ecosystems they depend on for their products can result in significant business and financial impact for them. Through insuring and investing in these companies, the insurance industry is also indirectly exposed to the decline of biodiversity. Hence the importance of integrating biodiversity considerations into investment decisions and engaging with companies to create value for both investors and companies.

What is AXA doing about biodiversity loss?
AXA's strategy focuses on two main areas: oceans and forests. Both are key to combating biodiversity loss and climate change and have direct relevance for AXA's business as an insurer. AXA's strategy operates on several fronts:

Insurance: AXA works directly with customers on environmental risk. The Group provides coverage for companies' liabilities, parametric solutions to the physical impacts of climate change, and offers advice on risk mitigation. AXA is now also looking to develop new, innovative products which include blue carbon credits and insurance for natural systems such as coral reefs and mangroves.

Investment: Biodiversity will be increasingly built into AXA's approach to responsible investment, through engaging with the companies the Group invests in and also through the launch in 2019 of a new impact fund for climate and biodiversity. The latter provides the Group with €200 million to invest in projects that protect natural habitats, and to deliver economic and social benefits to local communities.

Research: AXA is committed to research through its scientific philanthropy initiative, the Research Fund, and supports over sixty projects related to biodiversity, for a total of €10 million. Through this commitment, research will continue to provide a scientific basis for informed decision-making in insurance, investment and corporate responsibility.

Corporate responsibility: The fight against biodiversity loss will need broad action and requires stronger collaboration between the private and public sectors, as well as NGOs, which often have the expertise and local knowledge necessary for effective policy. In May 2019, AXA issued a series of recommendations jointly with WWF France[33] and urged governments to set clear priorities. Presented at the G7 meeting in Metz, the recommendations included:

• ***Setting up a Task Force on Nature Impact Disclosures,*** similar to the Task Force for Climate-Related Financial Disclosures (TCFD), established after the Paris Climate Conference in 2015.

[33] Recommendations from Into The Wild – Integrating Nature into Investment Strategies, published by WWF France and AXA.

The Task Force will examine ways for companies to assess and report their biodiversity risk as well as their strategy for dealing with that risk;

• ***Including biodiversity criteria in models*** used by leading non-financial rating agencies to assess companies' environmental, social and governance (ESG) performance[34] – at the same time, tightening up accreditation for these rating agencies;

• ***Developing a framework for investors*** to make it easier to analyze biodiversity risk, especially in vulnerable sectors such as agriculture, tourism and mining. An effective framework would allow the finance industry to engage more effectively with companies it invests in or lends to;

• ***Labelling financial products*** that have a positive effect on nature – this would raise public awareness, tap into consumers' increasing preference for ecofriendly products and help direct more investment to protecting biodiversity and natural resources.

$505 billion

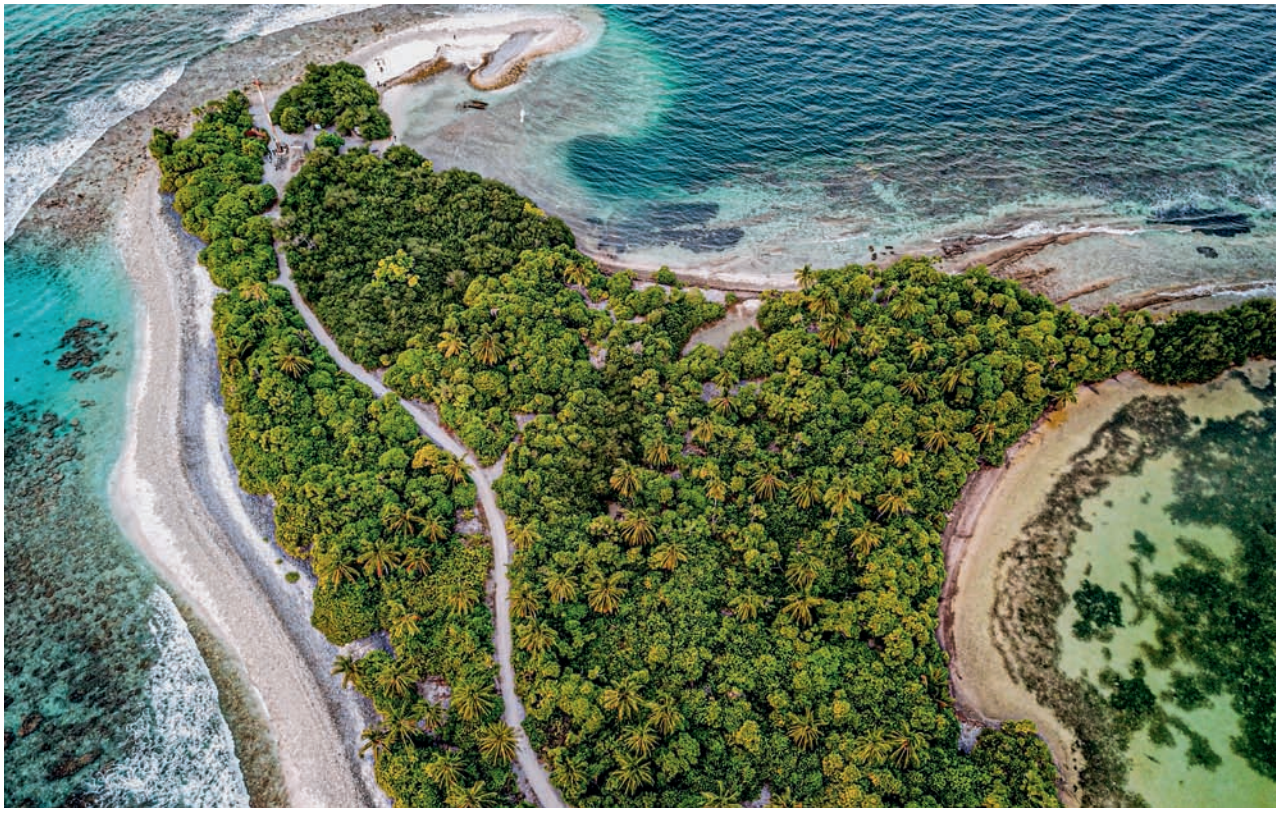
Economic losses from natural catastrophes in 2017 and 2018 together totaled more than $505 billion. Less than half of these losses were insured.
Source: Swiss Re Institute (2019)

-60%

The Living Planet Index shows a decline of 60% in the population sizes of wildlife over the past four decades; the index surveys the health of thousands of species and populations around the world.
Source: WWF /Zoological Society of London (2018)

70%

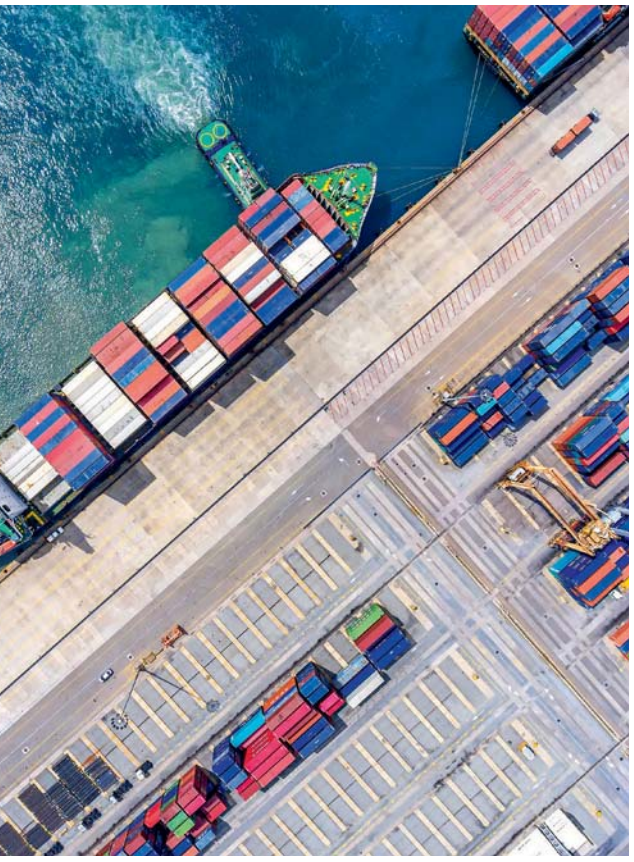
Seventy percent of drugs used to treat cancer are natural or synthetic products inspired by nature. In addition, some 60% of the world's population rely on traditional medicine, many of which are based on plants and herbs.
Source: IPBES (2019)



[34] ESG performance measures the sustainability aspect of companies' operations.

CORPORATE VIEW

Biodiversity and insurance



Biodiversity loss involves social, economic and environmental risks. The question is: how can insurance help? It is often insurers who foot the bill for economic losses – but they do much more than that. Insurers play a crucial role in providing risk coverage, which involves the pricing of risk, advising and protecting customers, and helping to minimize impact from adverse events that might notably include biodiversity loss.

Some insurance products such as risk pools and parametric insurance cover environmental risk and there is a growing market for environmental liability insurance. However, extending insurance to natural ecosystems such as wetlands and tropical forests is only just emerging. The challenge is to scale up insurance products, build more risk awareness, reach more people and communities, and provide effective long-term protection for natural resources. Adias Gerbaud, Aurélie Fallon Saint Lo and Chip Cunliffe from AXA XL as well as Mark Way from The Nature Conservancy, share their view on the role insurance can play in protecting nature.

$15 billion

Over the past five years, the US government has paid $15.2 billion in flood claims under the country's National Flood Insurance Program.
Source: FEMA (US Federal Emergency Management Agency) (2019)

Aurélie Fallon Saint-Lo,
Underwriting manager, Environmental risks – France & Benelux, AXA XL

"Companies' attitudes and standards have evolved – twenty years ago, some of the conversations were quite difficult to have. They are now more open to discussing their environmental impact. On one hand, there is a genuine desire to be more responsible; on the other, they no longer have a choice. The rise of social media means that you just cannot hide anything anymore. To support our customers, we not only offer traditional risk transfer, but also prevention, risk mitigation and crisis management services."

Environmental liability insurance

In 2007, the EU Environmental Liability Directive (ELD)[35] established the 'polluter pays' principle, acknowledging that those who cause pollution are liable for it and must take the necessary preventive or remedial action and bear all the costs, notably related to damage in the areas of human health and the environment. This helped raise awareness of environmental risks for private companies. Companies are now investing in sustainability and new regulations have been introduced in Europe. In France, for example, some cities now include a requirement for environmental insurance in large-scale building projects.

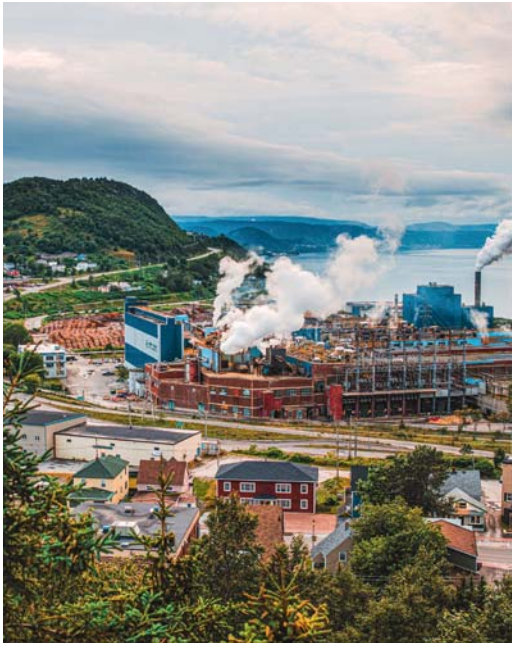
The ELD also broadened liabilities. While the focus had previously been on pollution and industrial accidents that would damage the local environment, companies can now be held liable for indirect damage as well – if a factory fire destroys nearby protected woodland, for example, or a business obstructs local access to water.

Take-up rates for environmental insurance, however, are patchy. Some countries, such as Spain, have made financial provisioning compulsory. In the United Kingdom, the National Farmers' Union included coverage in their insurance package for farmers. Elsewhere, many smaller businesses choose to forego coverage, in part because they lack clear data on potential clean-up and restoration costs. The result is that smaller businesses, often less 'regulated', may, paradoxically, be at greater risk.

Insurers cover risk, and they also help with prevention. AXA XL works with risk engineers in this area and with CEDRE – consultants specializing in water pollution. Regulators have an important role too: enforcing standards, tracking data on clean-up costs, allowing businesses to assess risk more accurately, and ensuring not only that fines are paid, but that companies also clean up damage and restore environments to their original condition.

Adias Gerbaud, *Head of Environmental Insurance International at AXA XL*

"Sixty percent of significant pollution incidents are caused by a failure of existing systems, or by human failure. The work has started, but governments need to do more to enforce legislation."



[35] EU Directive 2004 /35/ EC.

Chip Cunliffe, *Director of Sustainable Development, AXA XL*

"The insurance industry has a key role to play to increase resilience in the communities likely to be most impacted by ocean risk. Reefs, mangroves and other coastal ecosystems are of critical importance for coastal protection and disaster risk management. Through the development of financial and insurance products, we can redirect financial flows to ecosystem conservation and restoration and help close the protection gap."

Insurance for natural ecosystems
Different products are emerging based on the principle that, by protecting natural ecosystems, we can also protect people, property and livelihoods. Most of these work by putting an economic value on our natural resources.

Debt-for-nature swaps were created in the late 1980s. Some debt swaps cover tropical forests in Latin America and the Caribbean, while the Seychelles, for example, banned commercial fishing, oil exploration and economic development for around a third of its coastline in exchange for selling part of its national debt. These swaps protect natural ecosystems; they also provide a clear financial benefit, though they require effective enforcement. Governments may also use these alternatives to reschedule external debt.

Blue carbon credits work by combining traditional carbon credits with building resilience to natural disasters through investment in natural 'green' infrastructure (see above).

Insurance products, for their part have developed more recently: Swiss Re has launched a product to protect coral reefs in Mexico, along with TNC and the Mexican government. TNC was also behind the Seychelles debt-for-nature swap. The new TNC /Swiss Re product uses the concept of parametric insurance where pay-outs are triggered automatically by a given 'event' – in the case of coral reefs, when windspeeds reach a minimum of 100 knots. Importantly, the product has the backing of local hotel groups – premiums will be financed through an existing tax paid by owners of beachfront properties.

TNC wants to apply the same principle to other natural ecosystems and is working with AXA on possible insurance for mangroves, which help defend coastal communities from storm surges and flooding, for example in south-east Asia. In recent years, governments in this region have spent millions of dollars on restoring mangroves, and a new insurance product would help protect their investment. To local communities, these new products bring definite benefits such as a reduced reliance on man-made, 'grey' infrastructure, for example. They should also help close the 'protection gap' in countries where much of the population is still uninsured, as well as safeguard local jobs and livelihoods. The challenge now is to scale up these products and to do so quickly to attract more private sector investment in building resilience. Beyond current products, other opportunities are emerging such as providing credit insurance to fishermen in return for adopting more sustainable fishing practices.

Mark Way,
Global Coastal Risk and Resilience Director, The Nature Conservancy

"Awareness levels have gone up significantly. Hurricane Katrina was a shock - hurricane Sandy was another shock. Since then, there has been huge interest in what we can do to reduce vulnerability. Nature is definitely part of that question - and it will have to be a bigger part of the answer. The insurance industry can help by recognizing how nature reduces risk, design products to protect it and encourage investment in its restoration."

$82 billion

Without today's mangroves, flood damage would rise by more than $80 billion a year – and another 18 million people would be affected by flooding, two-thirds of them in just three countries: Vietnam, China and India.
Source: TNC, World Bank (2018)

Ocean Risk

It is clear that our oceans are changing, and changing fast. That has implications for coastal regions, for biodiversity, and for the lives and livelihoods of billions of people. An estimated 800 million are currently at risk from flooding because of storm surges and the rise in sea levels[36]. AXA has made oceans a key part of its biodiversity strategy with AXA XL leading the Group's work on ocean risk. It helped set up the Ocean Risk and Resilience Action Alliance (ORRAA), along with Ocean United, the Global Resilience Partnership and the Canadian government.

The aim is to better understand ocean risk and develop new financial products to drive investment in natural capital and build resilience in coastal communities. Key to this is ORRAA's public-private approach: there are now eleven governments involved – the G7 countries, Mexico, Norway, Fiji and India[37]. Work has already begun on an Ocean Risk Index which will provide a framework for assessing ocean risk and should, ultimately, make for better policy response.

[36] C40 Cities – Staying afloat, the urban response to sea level rise.
[37] Current full members of ORRAA are: AXA, Ocean Unite, Global Resilience Partnership, the government of Canada, Stockholm Resilience Centre, The Nature Conservancy, Willis Towers Watson and Rare.

CORPORATE VIEW

Biodiversity and investment

AXA is one of the world's leading institutional investors. Worldwide, the Group manages more than €1.4 trillion in investments. Our conversation with Julien Foll and Shade Duffy from AXA Investment Managers – an active, long-term, global, multi-asset investor that is part of the AXA Group – examines AXA's approach to investments.

Integrating biodiversity into investment decisions

AXA has a long history of responsible investment built into the Group's approach to investment management. Furthermore, AXA conducts extensive risk research into the companies in which it invests, covering environmental as well as social, governance and financial issues. Biodiversity is one of AXA's key topics within AXA's responsible investment approach, which translates into a strategic focus on policy, engagement and investment actions. Biodiversity is featured in the Group's investment policies, along with coal, tar sands and forestry. AXA's policy on palm oil, as an illustration, excludes investment in companies that do not have sustainability certification[38].

In recent years, AXA has been a frontrunner in climate change. Now, it is stepping up its work on nature – much of which stems from the essential role biodiversity plays for certain sectors and their potential impacts on nature itself, particularly food and agriculture, pharmaceuticals, mining and hydropower. The Deepwater Horizon oil spill in 2010 polluted over 2,000 kilometers of the United States' coastline, killing thousands of marine mammals, sea birds and sea turtles and contaminating their habitats[39]. Likewise, incremental damage to biodiversity may occur over the longer term. In the food and retail sector for instance, this may extend to raw material shortages as fish populations decline or as access to freshwater becomes more difficult. For all sectors, clean-up costs, fines and a damaged reputation pose a clear risk to returns on investment.

However, alongside the risks, there are opportunities, particularly for companies that manage resources responsibly. With consumer preferences evolving towards nature-friendly products, more 'certified' products are filling shelves of shops through initiatives like the Roundtable on Sustainable Palm Oil (RSPO), the Forest Stewardship Council (FSC) and Rainforest Alliance: Nearly a fifth of the world's palm oil is now RSPO-certified[40].

AXA has added biodiversity to its investment focus areas alongside health, gender and climate change. These focus areas guide AXA's approach to shareholder engagement and voting. AXA has an active engagement programme, working with the companies in which it invests as a shareholder and bondholder. The agri-food industry is a priority for engagement. Through standard practices, such as pesticide use, the industry has the potential to negatively impact biodiversity.

What is more, international food companies tend to have long and complex supply chains, which are often a source of risk. Through engagement, companies will be able to

Julien Foll, *Senior Responsible Investment Analyst, AXA Investment Managers*

"Among companies, there is a growing interest in the biodiversity topic as it connects social and environmental issues, attracting a growing interest within society as a whole. A responsible investor must address this issue and show support for the SDGs. It is especially critical that companies take into account their supply chains. If you look at retail and food companies, this is where most risks and opportunities occur."

$7 trillion

Implementing the UN SDGs by 2030 will cost an estimated $5-7 trillion. At the same time, achieving the goals could create $12 trillion in market opportunities and 380 million new jobs.
Source: UN Conference on Trade & Development (UNCTAD) (2018)

[38] AXA Investment Managers' exclusion covers companies that do not have, or have not committed to obtaining, certification from either the Roundtable on Sustainable Palm Oil (RSPO) or a similar internationally-recognized form of certification.
[39] The United States Department of Commerce (National Ocean Service).
[40] RSPO – volume of RSPO-certified palm oil (14.5 million tonnes, equivalent to 19% of global output).

CORPORATE VIEW

Shade Duffy, *Director of Impact Management, AXA Investment Managers*

"We really want to drive capital to the heart of the biodiversity challenge, in order to protect ecosystems and better promote biodiversity - this is what we are doing with the Climate and Biodiversity impact fund. Throughout the life of the fund, we will measure the impact we are having. Our expectation is that within the ten-year life cycle of the fund, we will have shown how the investments yielded profitable projects and generated proof of protecting natural capital at the same time - and at a scale that can be an example for other investors. This approach is about creating real-world outcomes. The social impact is just as important. If you do not also deliver better livelihoods for communities living close to natural capital sites, then that creates a risk. We want to align local communities' interests with the conservation agenda - and the best way to do that is to improve livelihoods."

identify their dependencies on biodiversity and set clear objectives to minimize any risk from these dependencies. For investors, there is a need for more data while, for companies, the need is to define metrics and performance targets to include in corporate reporting. This would not only make investment decisions clearer, but also facilitate comparisons between companies and sectors.

Investing for real-world impacts

As part of its approach, AXA also invests directly in natural ecosystems. In 2019, the Group announced the launch of a new ten-year 'Climate and Biodiversity' impact fund. The fund will invest up to €200 million and is a key part of the Group's overall strategy for biodiversity. The investment approach will be directed to three areas: conservation of natural capital, resource efficiency and increasing the resilience of vulnerable communities. AXA will invest the money while the Group's asset management business, AXA IM, will manage the investments. This is AXA's third impact fund – the other funds hold investments in health, education, financial inclusion and climate change. AXA's latest impact fund will use 'alternative assets', including private equity, private debt and project finance to invest in projects that will make a real-world difference. These projects will have to deliver financial returns, as well as tangible social or environmental benefits, which is the basis of impact investing. Similar projects include the Cordillera Azul national park in Peru in which AXA

and other investors provide financing for conservation and restoration. In return, they receive carbon credits, which can then be sold. In such projects, local buy-in is crucial. Investors at Cordillera Azul also fund agroforestry development, improving livelihoods for local communities and discouraging encroachment into protected forest areas.

AXA's new fund sets clear 'impact' goals: carbon emissions avoided, hectares of critical habitat protected, or the number of people whose 'climate resilience' has improved because of the fund's investments. There is also a clear link to the SDGs in that performance measures will be tied directly to their underlying targets and indicators. Five of the seventeen SDGs have been included in the fund's objectives: renewable energy, responsible consumption, climate action, life under water and life on land.

$550 million

AXA has commited €550 million in impact investments in climate and the environment, health, financial inclusion and education.
Source: AXA IM (2019)

81%

More than 4 in 5 consumers feel strongly that companies should care for the environment – the figure rises to 85% among millennials.
Source: Nielsen Research (2018)

About the AXA Research Fund

The AXA Research Fund, AXA's scientific philanthropy initiative, supports top-tier scientific research with the aim of better responding to the most important issues facing our planet today.

The Fund is committed to contributing to societal progress and disseminating researcher findings to inform public and private decision-making.

The Fund supports 650 scientific projects in 36 countries in the areas of health, the environment, new technologies, and socio-economics.

For more information, please visit: https://www.axa-research.org/

About AXA

AXA is one of the world's largest insurance companies, serving 105 million customers in more than 60 countries around the world. AXA provides property & casualty cover, life insurance, savings and retirement products and asset management to both retail and institutional investors. For more information, please visit: www.axa.com.

Main key Figures

€250 million
committed

650
research projects funded

300
academic institutions supported

36
countries

References and abbreviations

1. Business & Sustainable Development Commission - *Better Business, better world* (2017)
2. Centre for International Forestry Research (CIFOR) *Annual Report 2018*
3. C40 Cities *Staying afloat, the urban response to sea level rise (2018)*
4. Centre for Research on the Epidemiology of Disasters (CRED) *Natural Disasters, 2018*
5. Convention on Biological Diversity (CBD) *Aichi Biodiversity Targets (2013)* *Mountain biodiversity – why is it important? (2019)*
6. Crédit Suisse AG and McKinsey Center for Business and Environment, Conservation Finance *From Niche to Mainstream: the Building of an Institutional Asset Class, (2016)*
7. Federal Emergency Management Agency (FEMA) *Loss dollars paid per calendar year (1978-2018)*
8. Forest Carbon Partnership Facility (FCPF) *What is REDD+ (2019)*
9. Forest Stewardship Council (FSC) *Overview (United States) (2019)*
10. Intergovernmental Panel on Climate Change (IPCC) *Climate change and land (2019)*
11. Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) *General Assessment Report, Summary for Policymakers, 2019*
12. International Food Policy Research Institute *World trends in fertilizer use and projections to 2020 (2017)*
13. International Union for Conservation of Nature (IUCN) *-IUCN Red List of threatened species (2019)* *-Facts and figures on forests (2019)* *-IUCN UK Committee Peatland Programme (Briefing Note 1) (2014)*
14. Max Planck Gesellschaft *Dramatic decline of Bornean orangutans (2018)*
15. National Geographic *Half of the Great Barrier Reef is dead (2019)*
16. Nature (international scientific journal) *Mass balance of the Antarctic ice sheet from 1992 to 2017 (2018)*
17. Nature Communications *The global flood protection savings provided by coral reefs (2018)*
18. Nature Reviews Genetics *The rice genome revolution: from an ancient grain to Green Super Rice (Rod A. Wing, Michael D. Purugganan and Qifa Zhang) (2018)*
19. Nielsen Research *Global consumers seek companies that care about environmental issues (2018)*
20. Organisation for Economic Cooperation & Development (OECD) *-The Ocean Economy in 2030 (2016)* *-Biodiversity: Finance and the Economic and Business Case for Action (prepared for the meeting of the G7 in Metz, May 2019)*
21. Oxford University Press *Allee Effects in Ecology and Conservation (Franck Courchamp, Ludek Berec and Joanna Gascoigne, 2008)*
22. Ramsar Convention on Wetlands *-The Global Wetland Outlook (2019)* *-Wetlands: source of sustainable livelihoods (fact sheet) (2019)*
23. Royal Botanic Gardens, Kew *The State of the World's Plants, (2018)*
24. Swiss Re Institute *-Natural catastrophes and man-made disasters in 2018: 'secondary' perils on the frontline (Sigma) (2019)* *-Preliminary Sigma estimates for 2018: global insured losses of $79 billion are fourth highest on Sigma records (2019)*
25. The Nature Conservancy *Investing in a blue carbon future (2019)*
26. UK Met Office *Global climate in context as the world approaches 1°C above pre-industrial for the first time (2015-2019 – close to record-breaking year)*
27. UN Conference on Trade and Development (UNCTAD) *-Financing for SDGs: Breaking the bottlenecks of investment, from policy to impact (2018)*
28. UN Educational, Scientific and Cultural Organisation (UNESCO) *-Facts and figures on ocean acidification (2019)*
29. UN Environment Programme (UNEP) *-A Snapshot of the World's Water Quality* *-Global Mercury Assessment, 2018*
30. UN Food & Agricultural Organisation (FAO) *-FAO Statistical Pocketbook (2018)* *-The State of the World's Biodiversity for Food and Agriculture (2019)* *-Mountains and Freshwater (2003)* *-Global agriculture towards 2050 (High-level Expert Forum) (2009)* *-State of the World's Forests (2016)*
31. UN Department for Social and Economic Affairs *-UN World Population Prospects (2019)* *-Revision of World Urbanisation Prospects (2019)*

References and abbreviations

32. UN International Migration Report (2017)

33. University of British Columbia
Boom or Bust: the future of fish in the South China Sea (2015)

34. US Department of Commerce (National Ocean Service)
Deepwater Horizon oil spill – long-term effects on marine mammals, sea turtles (2017)

35. World Bank
-Beyond scarcity – water security in the Middle East and North Africa (2017)
-The Changing Wealth of Nations (2018)
-The miracle of mangroves for coastal protection (2018)

36. World Cities Culture Forum
Percentage of public green space (parks and gardens) (2019)

37. WorldFish
From local to global: how research enables resilient and sustainable small-scale fisheries (2019)

38. World Health Organisation (WHO)
-Environmental and occupational health hazards associated with artisanal and small-scale gold mining (2016)
-Climate change and human health (2003)

39. World Resources Institute
The world lost a Belgium-sized area of primary rainforests last year (2019)

40. WWF (Worldwide Fund for Nature)
-Into the Wild – integrating nature into investment strategies (WWF France and AXA) (2019)
-Living Planet Index (WWF and Zoological Society of London) (2018)

41. Zoological Society of London
Living Planet Index (WWF and Zoological Society of London) (2018)

AXA IM	AXA Investment Managers
BNI	Biological nitrification inhibition
CBD	Convention on Biological Diversity
CIFOR	Centre for International Forestry Research
CNRS	National Council for Scientific Research (France – Conseil National de la Recherche Scientifique)
CRED	Centre for Research on the Epidemiology of Disasters
CSR	Corporate Social Responsibility
EcoLab	Functional and Environmental Ecology Laboratory (Toulouse, France)
ELD	Environmental Liability Directive (EU)
ENSAT	Ecole Nationale Supérieure Agronomique de Toulouse (School of Agronomy)
EPE	Entreprises pour l'Environnement
ESG	Environmental, Social and Governance
FAO	United Nations' Food & Agriculture Organisation
FCPF	Forest Carbon Partnership Facility
FEMA	Federal Emergency Management Agency
G7	Group of Seven (members: Canada, France, Germany, Italy, Japan, the United Kingdoland the United States)
GDP	Gross Domestic Product
IDF	Insurance Development Forum
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IPCC	Intergovernmental Panel on Climate Change
IRRI	International Rice Research Institute
IUCN	International Union for the Conservation of Nature
NGO	Non-Governmental Organisation
OECD	Organisation for Economic Cooperation & Development
ORRAA	Ocean Risk and Resilience Action Alliance
PSI	Principle for Sustainable Insurance
REDD+	Reduce Emissions from Deforestation and Forest Degradation
RSPO	Roundtable on Sustainable Palm Oil
SDG	Sustainable Development Goal
TCFD	Task Force for Climate-Related Financial Disclosures
TNC	The Nature Conservancy
UNCTAD	UN Conference on Trade & Development
UNEP	United Nations Environment Programme
UNESCO	UN Educational, Scientific and Cultural Organisation
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
WHO	World Health Organisation
WMO	World Meteorological Organisation
WRI	World Resources Institute
WWF	World Wide Fund for Nature

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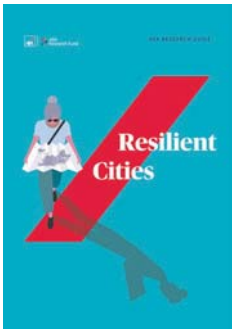

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