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NATURE IN CRISIS: BIODIVERSITY LOSS AND ITS CAUSES

HEARING

BEFORE THE

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
HOUSE OF REPRESENTATIVES

ONE HUNDRED SIXTEENTH CONGRESS

FIRST SESSION

JUNE 4, 2019

Serial No. 116–24

Printed for the use of the Committee on Science, Space, and Technology

Available via the World Wide Web: http://science.house.gov

U.S. GOVERNMENT PUBLISHING OFFICE
36–504PDF WASHINGTON : 2020

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NATURE IN CRISIS: BIODIVERSITY LOSS AND ITS CAUSES

TUESDAY, JUNE 4, 2019

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
Washington, D.C.

The Committee met, pursuant to notice, at 10:02 a.m., in room 2318 of the Rayburn House Office Building, Hon. Eddie Bernice Johnson [Chairwoman of the Committee] presiding.

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES
HEARING CHARTER

"Nature in Crisis: Biodiversity Loss and its Causes"
Tuesday, June 4, 2019
10:00 a.m.
2318 Rayburn House Office Building

PURPOSE

The purpose of this hearing is to discuss the major findings of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) summary for policymakers of their first Global Assessment Report.[1] The comprehensive review found that "nature's dangerous decline is unprecedented," and that one million species - 25% of global species in assessed groups - are threatened with extinction. This report also identifies potential pathways and solutions to implement *transformative change* to addressing the biodiversity loss described in the report. This hearing will serve as an opportunity to not only discuss the findings of the report, but to identify knowledge gaps and solutions for dealing with human-driven biodiversity loss.

WITNESSES

- **Sir Robert (Bob) Watson,** Past Chair, Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES)
- **Dr. Kate Brauman,** Coordinating Lead Author, IPBES Global Assessment; Lead Scientist, Global Water Assessment, University of Minnesota, Institute of the Environment
- **Dr. Steven Monfort,** Director of the Smithsonian National Zoo and Smithsonian Conservation Biology Institute
- **Mr. Jeff Goodwin,** Conservation Stewardship Lead & Agricultural Consultant, Noble Research Institute
- **Dr. James Porter,** Josiah Meigs Distinguished Professor, *Emeritus*, University of Georgia, and Scientific Advisor, *Chasing Coral*

OVERARCHING QUESTIONS

- What are the major findings of the IPBES report?
- How have direct drivers, such as climate change and pollution, impacted biodiversity?
- What are the potential impacts of biodiversity loss on human health?
- What knowledge gaps remain for understanding drivers and impacts of biodiversity loss?
- What are some potential solutions to stem human-caused biodiversity loss?
- How can we achieve the *transformative change* outlined in the report?

[1] IPBES. Global Assessment Summary for Policymakers. 2019.
https://www.ipbes.net/sites/default/files/downloads/spm_unedited_advance_for_posting_htn.pdf

BACKGROUND

In early May 2019, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) released their first Global Assessment Summary for Policymakers on biodiversity and ecosystem services.[2] The full 1,800 page Global Assessment was released on May 31, 2019.

The IPBES was established in 2012 as an independent intergovernmental body open to all members of the United Nations, but is not a United Nations body.[3] The IPBES does not conduct new science, but produces synthesis reports in a process similar to the Intergovernmental Panel on Climate Change (IPCC). Over 130 countries participated in the IPBES Global Assessment, with almost 500 experts reviewing 15,000 publications. Representatives of these government met in late April 2019 to finalize and approve the specific language in the Summary for Policymakers.

The Global Assessment is meant to help inform the Convention on Biological Diversity meeting in 2020. The Convention on Biological Diversity is a multilateral treaty between 196 parties that was first established in 1992; the United States is the only United Nations member state not to ratify the treaty. The International Union for Conservation of Nature (IUCN) has endorsed the IPBES Global Assessment and its findings.[4]

Summary of the Global Assessment report

The IPBES Global Assessment describes the immense and varied ecosystem services that are provided to mankind as a result of biodiversity around the globe. It also outlines a profound change in global ecosystems that has accelerated aggressively in the past fifty years. IPBES explains that nature underpins all aspects of human health and the global economy, so any decline of nature's contributions to people will adversely impact human health and the economy. As the human population doubled since 1970, the global economy has grown fourfold, greatly increasing global demand for energy and materials.

The Global Assessment outlines five direct drivers of biodiversity loss, in order of the largest global impact:

(1) changes in land and sea use
(2) direct exploitation of organisms
(3) climate change
(4) pollution
(5) invasive species

These direct drivers are primarily a result of human activity. The indirect drivers of change are underpinned by societal values and behaviors that include (1) production and consumption

[2] IPBES. Global Assessment for Policymakers. 2019.
[3] https://www.ipbes.net/about
[4] IUCN. https://www.iucn.org/news/global-policy/201905/iucn-welcomes-intergovernmental-platforms-assessment-biodiversity-and-ecosystem-services

patterns (2) human population dynamics and trends (3) technological innovations and (4) governance (from the most local levels to the global/multinational).

The Global Assessment finds that the sustainability goals for 2030 and 2050 articulated via the Convention on Biological Diversity, the UN Framework Convention on Climate Change (UNFCCC) and the 2050 Vision for Biodiversity cannot be met under current trajectories for continued biodiversity loss. It argues that these goals can be met only with urgent and concentrated efforts toward *transformative change,* which is described as a "fundamental, system-wide reorganization across technological, economic, and social factors, including paradigms, goals, and values." In addition to synthesizing the impacts of both direct and indirect drivers of biodiversity loss on our ecosystems, the Global Assessment provides approaches for sustainability and potential pathways to achieve transformative change and highlights some outstanding knowledge gaps. The Science Committee has a role to play in helping to address these knowledge gaps through scientific discovery, which can help implement solutions to biodiversity loss.

Some of the major findings, approaches to sustainability, and knowledge gaps identified in the Global Assessment are summarized below.

Key Findings

- Three-quarters of land surface has been significantly altered by human activity
- Two-thirds of ocean area is experiencing increasing cumulative impacts
- Over 85% of wetlands by area have been lost due to human drivers
- Approximately 1 million species may face extinction in the next few decades unless action is taking to stem biodiversity loss
- The disappearance of different varieties and breeds of domestic plants and animals threatens global food security
- Many organisms are rapidly evolving, some over the course of only a few years, in response to anthropogenic drivers
- Agriculture production trends since 1970 are not sustainable.
    - While the aggregate value of crop and timber production has increased drastically in the last generation, fourteen of the 18 categories of contributions of nature, such as soil organic carbon, have declined over the same time period.
- $235-577 billion in annual global crop output is at risk due to loss of pollinators (i.e. bees).
- Half of the live coral cover on coral reefs has been lost since the 1870s.
    - The loss of coastal habitats and coral reefs puts the 100-300 million people that live in coastal communities at increased risk of hurricanes and floods
- Land-use change (driven by agriculture, forestry, and urbanization) is the largest negative impact on terrestrial and freshwater ecosystems, followed by direct exploitation
- One third of the terrestrial land surface is dedicated to cropping or animal husbandry.
    - Agricultural expansion is the most widespread form of land use change
- For marine ecosystems, direct exploitation (such as fishing) has had the largest negative impact, followed by land/sea-use change

- Many types of pollution and invasive alien species are increasing and having negative impacts on nature
- Marine plastic pollution has increased tenfold since 1980
- The cumulative record of invasive species has increased by 40 percent since 1980
- Areas around the world that will be most impacted from global changes in climate, biodiversity, and ecosystem services are home to the largest concentrations of indigenous people and many of the world's poorest communities.
- Climate change is a direct driver of change that exacerbates the other direct drivers
- The negative impacts of climate change as a driver of change will increase with increased global temperatures
- The overall state of nature continues to decline, with 12 of 16 indicators showing worsening trends

Approaches for sustainability and pathways to achieve transformative change

- Promoting cross-sector approaches to governance through stakeholder engagement and inclusion of local communities and indigenous people
- Ensuring policy decisions are informed by a complete understanding of nature's contributions to people
- Producing and consuming food sustainably
- Integrating multiple uses for sustainable forests
- Conserving, effectively managing and sustainably using terrestrial landscapes
- Promoting sustainable governance and management of ocean ecosystems
- Improving freshwater management, protection, and connectivity
- Building sustainable cities
- Promoting sustainable energy and infrastructure
- Improving the sustainability of economic and financial systems

Knowledge gaps

- Data, inventories and monitoring on nature and drivers of change
- Gaps on biomes and units of analysis
- Taxonomic gaps
- Nature's contribution to people gaps
- Links between nature, nature's contributions to people and drivers with respect to targets and goals
- Integrated scenarios and modeling studies
- Potential policy approaches
- Indigenous peoples and local communities

ADDITIONAL READING

Millennium Ecosystem Assessment
https://www.millenniumassessment.org/en/Global.html

International Union for the Conservation of Nature (IUCN): Red List of Threatened Species
www.iucnredlist.org

Living Planet Index
www.livingplanetindex.org

Chairwoman JOHNSON. This hearing will come to order. Without objection, the Chair is authorized to declare a recess at any time. I want to say good morning, and welcome to today's Full Committee hearing, entitled, "Nature in Crisis: Biodiversity Loss and its Causes". I'd like to welcome our distinguished panel of witnesses, and thank all of you for joining us.

Today we have the opportunity to discuss an issue that captivated the attention of the public and policymakers alike, namely the alarming loss in biodiversity that is occurring worldwide. As a matter of fact, I read a paper in France last week on this very subject. The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, or the IPBES, recently published a summary for policymakers (SPM) for its first ever global assessment report. This intergovernmental body, which is not a part of the United Nations, set out to assess the state of biodiversity, its ecosystems, and the essential services they provide to society. The global assessment was prepared in advance of the upcoming UN Convention on Biological Diversity scheduled for 2020. I'd like to note that while we are primarily discussing the findings of the summary for policymakers today, the draft chapters of the full report were recently made publicly available. The final report chapters will be released later this year, and they will not differ from the findings in the summary for policymakers that we are discussing this morning.

The findings of IPBES laid out are too stark to ignore. The global assessment lays out the direct drivers of biodiversity loss in the following order, from the greatest to least impact. Changes in land and sea use, direct exploitation of organisms, climate change, pollution, and invasive species. Though there are many underlying causes for these direct drivers of change, it is very clear that humans have had an outsized impact on our surrounding environment. We've already discussed the impacts that our change in climate is having on our oceans at our Environmental Subcommittee hearing earlier this year, but climate change as a driver of biodiversity loss also impacts non-marine ecosystems. I look forward to hearing from each of our witnesses about the real-world impacts of all of the drivers of this biodiversity loss.

Much of the reporting on the global assessment is focused on the devastating findings that almost one million species could potentially go extinct in the next few decades. But we would be remiss if we did not discuss what else the report lays out, especially its recommendations for potential solutions and pathways for addressing biodiversity loss. I hope today's conversation with our witnesses will provide an opportunity to further illuminate potential solutions we can utilize to address the dangers highlighted in the global assessment.

Earlier this year, I introduced the *Energy and Water Research Integration Act*, with my friend and colleague Ranking Member Lucas, to address issues related to water conservation and use in the process of the Department of Energy's research, development, and demonstration activities. Cross-cutting initiatives, like this bill, are clear examples of the role that Congress, and especially this Committee, can play in developing science-based solutions to our most pressing issues.

June is World Oceans Month, and this week in particular is Capitol Hill's Oceans Week, or CHOW. I'm delighted that we have Dr. Porter from the University of Georgia joining us today to discuss the impacts of the drivers of biodiversity loss laid out in the IPBES report on coral reefs, and the numerous ecosystem services they provide. Later today the Committee will be screening *Chasing Coral*, a film for which Dr. Porter was a scientific expert. The screening is free and open to the public, and I encourage everyone to come back and watch it. After the screening, Dr. Porter will host a question and answer session with the audience. I want to let everyone know that this Thursday, June 6, the Committee will be hosting an Ocean Exploration Expo to showcase ocean exploration technologies. I again encourage members of the public, and any of my colleagues, to join this Expo on Thursday. More important, more information is available on our website. I would also like to welcome back Sir Robert Watson, who previously testified before our Committee over 20 years ago.

I am really looking forward to today's discussion to not only better understand the findings of the IPBES Global Assessment Report, but also identify knowledge gaps, understand how best to implement the transformative changes recommended, and determine our path forward with science-based solutions. Thank you.

[The prepared statement of Chairwoman Johnson follows:]

Good morning. I would like to welcome our distinguished panel of witnesses and thank them for joining us. Today we have the opportunity to discuss an issue that has captivated the attention of the public and policymakers alike, namely the alarming loss in biodiversity that is occurring world wide.

The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, or IPBES, recently published a summary for policymakers for its first ever Global Assessment Report. This intergovernmental body, which is not a part of the United Nations, set out to assess "the state of biodiversity, its ecosystems, and the essential services they provide to society." This Global Assessment was prepared in advance of the upcoming UN Convention on Biological Diversity scheduled for 2020.

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We have already discussed the impacts that a changing climate is having on our oceans at an Environment Subcommittee hearing earlier this year, but climate change as a driver of biodiversity loss also impacts non-marine ecosystems. I look forward to hearing from each of our witnesses about the real world impacts of all of the drivers of biodiversity loss.

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I am really looking forward to today's discussion to not only better understand the findings in the IPBES Global Assessment report, but also identify to knowledge gaps, understand how best to implement the transformative changes recommended, and determine our path forward with science-based solutions.

Thank you.

Chairwoman JOHNSON. I now ask Mr. Lucas for his statement.

Mr. LUCAS. Madam Chair, thank you, and before starting my statement, I'd like to take a second to recognize one of our senior policy folks, Ben Traynham, who's sitting up here with us. This is his last hearing before he leaves D.C. and returns to Richmond, Virginia. Ben's moving home to practice law, to grow his family, with their second daughter due this fall. I want to thank Ben for his hard work. We'll miss that signature bowtie, even if it is kind of un-Western Oklahomish, and we wish you great success with your coming steps. So, thank you, Madam Chair, for indulging me on that courtesy.

Now, Madam Chair, thank you for holding this hearing, and providing a platform to hold constructive dialog on this issue. I'm going to read it one time, and here ever after I'm going to refer to it as the report, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services' Global Assessment Report on Diversity in Ecosystems is a 1,700-page report that was just released yesterday morning. I'll be the first to admit to you that I have not read the complete report, and I admire any of my colleagues who have found time to do so. The purpose of this hearing is to examine the report's summary for policymakers. And while I welcome today's discussion, I'd be remiss if I didn't say maybe waiting a week or so, a little time to read it in full, and understanding of the process, would've been useful, but those conclusions will serve us nonetheless.

With what is being said, I look forward to a productive discussion on how we can use innovation to combat the most pressing changes in global biodiversity. Biodiversity, or the variability of species in ecosystems, plays a significant role in all aspects of human wellbeing. It's particularly important to agricultural producers, who lead a system that feeds and clothes billions of people every day. The report ranks land and sea use at the top of their five biggest drivers of change in nature, and concludes that agricultural expansion is the most widespread form of land use change. This expansion of agricultural land is a direct result of the need to feed the growing population.

The global population is on track to reach nearly 10 billion people by 2050, and the UN Food and Agricultural Association esti-

mates that global food production will need to double by that time. Now, that's why we must support innovation and research that will help make food production more efficient and environmentally beneficial. Increasing production, while eliminating waste of all kinds, including land waste, is a goal of any operation. The best way to accomplish this in agriculture is utilizing modern science and conservation principles, coupled with proven management practices.

The United States has been the model of conservation through voluntary coordination and innovation, and we must continue to carry that torch. Following the immense soil erosion and drought of the Dust Bowl in the 1930s, Federal, State, and local governments partnered with producers to solve the disaster. President Franklin D. Roosevelt's administration initiated programs to conserve soil and restore the ecological balance of the Nation, with producers leading the way. These U.S. programs and institutions, that incentivize conservation, have been incredibly successful, and are still in effect today.

We've also benefited from innovations like those of Nobel Peace Prize recipient Dr. Norman Borlaug, who developed varieties of semi-dwarf, high-yield, disease-resistant wheat. This variety's introduction in India and Pakistan during the population boom of the 1960s is credited with starting the Green Revolution, and saving up to one billion people from starvation. There are even more exciting innovations on the horizon. Genetic engineering, gene editing, have the potential to produce plant varieties that require less land, less water, less fertilizer, while increasing biodiversity. This next generation of crop genetics are closer than we think, and current investments in research will pay unmeasurable dividends in the future.

One of our witnesses today, Dr. Jeff Goodwin, will discuss efforts at the Nobel Research Institution to increase soil health and productivity through improved land management techniques. Mr. Goodwin will speak to voluntary agricultural conservation practices led by producers that should serve as a model for different industries. We've seen incredible success from these industry-led efforts without resorting to burdensome regulations.

In closing, I'd like to remind my colleagues of this Committee's jurisdiction. This topic walks a fine line with the Natural Resources Committee, so I encourage my colleagues focus on research and innovation that can be used as solutions, not the doom and gloom of predicting what might happen in the future. Too often we are bogged down by the alarming negative headlines that stem from these reports. What I see is another opportunity to revolutionize. I see another opportunity for the United States to show yet again we're the best in the world at solving the daunting and complex problems we all face. I look forward to hearing more on technological innovations and environmental stewardship that looks to improve our critical biodiversity, while promoting economic growth. Thank you, Madam Chair, and I yield back the balance of my time.

[The prepared statement of Mr. Lucas follows:]

Thank you, Chairwoman Johnson, for holding this hearing and providing a platform to hold constructive dialogue on this issue.

The IPBES Global Assessment Report on Biodiversity and Ecosystem Services is a 1,700-page report that was just released yesterday morning. I will be the first to admit I have not read the complete report and I admire any of my colleagues who

found the time to do so. The purpose of this hearing is to examine the report's Summary for Policymakers.

While I welcome today's discussion, I would be remiss if I didn't say that waiting a week or two for time to read the full report and understand the underlying process used to reach conclusions would serve us better.

With that being said, I look forward to a productive discussion on how we can use innovation to combat the most pressing changes in global biodiversity.

Biodiversity, or the variability of species and ecosystems, plays a significant role in all aspects of human well-being. It's particularly important to agricultural producers who lead a system that feeds and clothes billions of people every day.

The IPBES report ranks land and sea use at the top of their five biggest drivers of change in nature and concludes that agricultural expansion is the most widespread form of land use change. This expansion of agricultural lands is a direct result of the need to feed the growing population.

The global population is on track to reach nearly 10 billion people by 2050, and the UN Food and Agriculture Association estimates that global food production will need to double by that time. That is why we must support innovation and research that will make food production more efficient and environmentally beneficial.

Increasing production while eliminating waste of all kinds, including land waste, is the goal of any operation. The best way to accomplish this in agriculture is utilizing modern science and conservation principles coupled with proven management practices.

The United States has been the model of conservation through voluntary coordination and innovation, and we must continue to carry that torch. Following the immense soil erosion and drought of the Dust Bowl, federal, state, and local governments partnered with producers to solve the disaster.

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Too often we are bogged down by the alarmingly negative headlines that stem from these reports. What I see is another opportunity to revolutionize. I see another opportunity for the United States to show yet again that we are the best in the world at solving the daunting and complex problems we all face.

I look forward to hearing more on technology innovations and environmental stewardship that looks to improve our crucial biodiversity while promoting economic growth. Thank you Madam Chair and I yield the balance of my time.

Chairwoman JOHNSON. Thank you very much, Mr. Lucas. If there are Members who wish to submit additional opening statements, your statements will be added to the record at this point. At this time I'd like to introduce our witnesses.

Sir Robert Watson served as the IPBES Chair from 2015 to 2019. He is a leader in the field of environmental science, and has spent much of his distinguished career focusing on the impacts human

activity has had on Earth. Currently, Dr. Watson is Professor of Environmental Sciences at the University of East Anglia in Norwich, England. He also serves as Director of Strategic Development of the Tyndall Center for Climate Change Research at the University.

Dr. Kate Brauman is a coordinating lead author for the 2019 IPBES Global Assessment. Dr. Brauman also served as a lead scientist for the Global Water Initiative at the University of Minnesota, Institute on the Environment.

Dr. James Porter is an Emeritus Professor at the University of Georgia, Odum School of Ecology. Dr. Porter's research focuses on coral reef ecology and conservation, as well as marine life ecosystems.

Mr. Jeff Goodwin is a conversation stewardship leader and a pasture and range consultant at the Nobel Research Institute based in Ardmore, Oklahoma. Prior to his current position, Mr. Goodwin worked for the U.S. Department of Agriculture, Natural Resources Conservation Service, for nearly 14 years.

Last, we have Dr. Steven Monfort. Dr. Monfort is Director of the Smithsonian National Zoo and Conservation Biology Institute. He holds a Ph.D. in Environmental Science and Public Policy, as well as a doctorate degree in veterinary medicine.

Our witnesses should know that you each have 5 minutes for your spoken testimony. Your written testimony will be included in the record for the hearing. When all of you have completed your spoken testimony, we will begin with questions. Each Member will have 5 minutes to question the panel.

We will start with Dr. Watson.

TESTIMONY OF SIR DR. ROBERT WATSON, PAST CHAIR, INTERGOVERNMENTAL SCIENCE-POLICY PLATFORM ON BIODIVERSITY AND ECOSYSTEM SERVICES

Dr. WATSON. Thank you, Madam Chair, and Members of the Committee. I really appreciate the opportunity to provide this testimony, which is indeed based on the IPBES Global Assessment of Biodiversity and Ecosystem Services. As Madam Chair said, IPBES is an intergovernmental body, but it is independent of the United Nations. The assessment was prepared by 450 scientists. We used 15,000 sources of information, and received 15,000 comments during two rounds of expert and government peer review. The chapters and the SPM are now all available on the IPBES website.

Biodiversity, which is critical to human wellbeing, provides food, as indeed has been mentioned already, fiber, water, energy, and medicines. It regulates our climate, our air, our water pollution, storm surges, floods, and pollination, and has significant cultural and social value. Biodiversity is currently being lost at a rate unprecedented in human history, primarily driven by changes in land and sea use, and direct exploitation of organisms, and, to a lesser extent, to date, by climate change, pollution, and invasive alien species. These all result from increases in the number of humans and per capita consumption, trade, technological innovations, and governance systems, local to global. These losses in biodiversity are undermining human wellbeing, especially the regulating and cultural services.

While climate change has not been the dominant driver in the loss of biodiversity to date in most parts of the world, it is projected to become as important, or potentially more important, than other drivers of change in the coming decades. Climate change is already adversely affecting genetic variability, species richness, populations' composition and distributions, and the boundaries, structure, and functioning of ecosystems. These changes are evident and accelerating, in marine, terrestrial, and freshwater systems. Almost half of the threatened terrestrial mammals, and one-quarter of threatened birds, may already have been negatively affected by climate change. In turn, biodiversity can adversely affect the Earth's climate. For example, deforestation increases the atmospheric abundance of carbon dioxide, a key greenhouse gas, therefore it's essential that we look at the issues of biodiversity and climate change together.

In addition to transforming the way we produce and use energy, there are many nature-based approaches that can be used to adapt to, or mitigate, human-induced climate change. Large-scale reforestation, ecosystem restoration. However, it is important to recognize that some of the approaches that have been suggested to limit human-induced climate change, such as large-scale afforestation, and large-scale bioenergy, will adversely affect biodiversity, and food and water security, if natural vegetation, grasslands and forests, are replaced by monoculture bioenergy crops. So we have to think through very carefully how we use afforestation and bioenergy.

Loss of biodiversity, just like human-induced climate, is not only an environmental issue, but it's an economic, development, social, security, moral, and ethical issue. The loss of biodiversity is projected to continue or worsen in many future scenarios. Business as usual is not an option if the world wants to conserve, and sustainably use biodiversity, and meet sustainable and societal goals, such as food and water security. Scenarios show that the impact of climate change is projected to intensify with the degree of warming. For instance, in a climate change risk assessment, 5 percent of species are at risk at 2 degree warming, rising to 16 percent with a 4.3 degree warming.

Current and future projected trends in biodiversity will undermine many of the internationally agreed Aichi biodiversity targets. They will undermine the sustainable development goals, all 17 of them, and it will undermine the Paris agreement on climate change. And, in particular, it will threaten poverty, hunger, human health, water, cities, and life on land.

With that, Mr. Chairman, I'd like to close my remarks. Madam Chair, apologies.

[The prepared statement of Dr. Watson follows:]

An Overview of the IPBES Global Assessment on Biodiversity and Ecosystem Services: Highlighted Findings and Contributions

Robert Watson, past chair of IPBES

I would like to thank the House Committee on Science, Space and Technology for the opportunity to provide a testimony based on the *global assessment report on biodiversity and ecosystem services* of the Intergovernmental Science-Policy Platform for Biodiversity and Ecosystem Services (IPBES). I would like to note that all chapters and the SPM are now available on the IPBES web site. This testimony complements that provided by Dr Kate Brauman.

A. A brief overview of the global assessment process:
The global assessment is the first intergovernmental assessment to critically assesses the state of knowledge on past, present and possible future trends of nature and its contributions to people (which embody biodiversity and ecosystem functions and services[1]), the drivers of such changes, their projections and scenarios into the future, and possible pathways and options to meet internationally-agreed goals. Five overarching questions define the scope of the assessment[2]. The geographic coverage includes land, inland waters, coastal zones and oceans, analyzed as appropriate at the level of biomes, ecosystems, species, varieties and breeds. Eighteen categories of nature's contributions and ecosystem services are analyzed. The timeframe examined in the assessment includes going back as far as 50 years, so that current status and trends up to 2020 can be seen in context. Scenarios and plausible future projections are examined with a focus on various periods between 2020 and 2050, for which possible pathways to and options for sustainability across sectors are analyzed. Furthermore, the global assessment provides a framework for analyzing interdependencies between the internationally agreed 2030 Sustainable Development Goals, the 2050 Vision for Biodiversity, the Paris Agreement on Climate Change, and several Environmental Conventions. The assessment was timed to be a major input to the Convention on Biological Diversity's fifth edition of the Global Biodiversity Outlook and its second edition of the Local Biodiversity Outlook, informing the process leading up to the new post-2020 biodiversity framework.

Following this overarching structure, the global assessment was undertaken during a period of three years, based on the voluntary work of 3 co-chairs, 142 nominated experts coordinating and lead authors (CLAs and LAs)[3], review editors, fellows and 310 contributing authors (CAs), a dedicated technical supporting unit, 6 supporting scientists, 1 resource person and a management committee. The final report is the result of multiple levels of co-production involving multidisciplinary collaboration, consideration of different knowledge systems, multiple rounds of open reviews (15,000 comments were received during two rounds of expert and government review), revisions and responses, meetings and consultations with representatives of governments and of Indigenous peoples and local communities, as well as an online call for contributions. The majority of the sections of the report is based on systematic literature review (with a final selection of around 15,000 references), complemented by expert knowledge reviews, and a wide array of data, indicators, reports, and geospatial datasets, compiled, as available and appropriate, from local to global levels[4]. The global assessment is also the first global level assessment to implement a concerted effort to

[1] The Global Assessment Scoping Report (section III of its decision IPBES-4/1, 2016):
[2] What is the status of and trends in nature, nature's contributions to people and indirect and direct drivers of change? How do nature and its contributions to people influence the implementation of the Sustainable Development Goals? What is the evidence base that can be used for assessing progress towards the achievement of the Aichi Biodiversity Targets? What are the plausible futures for nature, nature's contributions to people and their impacts on quality of life between now and 2050? What pathways and policy intervention scenarios relating to nature, nature's contributions to people and their impacts on quality of life can lead to sustainable futures? What are the opportunities and challenges, as well as options available to decision makers, at all levels relating to nature, its contributions to people and their impacts on quality of life?
[3] Nominated authors from 51 countries.
[4] It's important to note that, as other assessments, the global assessment has not undertaken new primary research, but analyzed, synthetized and critically evaluated available data, information, and evidence previously published or otherwise made available in the public domain in a traceable way.

include a diversity of worldviews and knowledge systems including systematic analyses of evidence on Indigenous and local knowledge and issues.

B. Summary of Key Findings:

The global assessment showed that societal impacts on land, freshwater, and oceans have accelerated significantly during the past 50 years, a rate unprecedented in human history, aggregating to global level changes in the biosphere and atmosphere, which are increasingly interacting and having compounding and cascading effects on biodiversity, ecosystems, and society, at all levels. On the aggregate, 75% of the land surface is significantly altered, 66% of the ocean area is experiencing increasing cumulative impacts, and over 85% of wetlands (area) have been converted. Both the contributions to and the consequences of these changes are distributed unevenly and unequally across regions and society. No matter where people live, the report shows that nature plays a critical role in providing food and feed, water, energy, medicines and genetic resources and a wide array of materials fundamental for people's physical well-being and for maintaining culture. A significant array of contributions, particularly the (largely invisible to society) regulating contributions provided by ecosystems (e.g., regulating climate, pollution, water quality, pollination, floods and storm surges) and non-material contributions e.g., (learning and inspiration, physical and psychological) are currently declining and/or projected to decline, with unequal consequences for different sectors of society.

The direct drivers of change in nature with the largest global impact have been (starting with those with most impact): changes in land and sea use; direct exploitation of organisms; climate change; pollution; and invasion of alien species. Those five direct drivers result from an array of underlying causes – the indirect drivers of change – which are in turn underpinned by societal values and behaviours that include production and consumption patterns, human population dynamics and trends, trade, technological innovations and local through global governance.

The assessment shows that societal responses, including successes, are also evident from local to global levels, and that more sustainable pathways forward are possible. While progress has been made on many fronts, the great majority of indicators of ecosystems and biodiversity, and their benefits to society continue to show decline, marked by clear regional differences. These trends are projected to continue or worsen in many future scenarios. Current trends will undermine most of the internationally agreed 2020 Aichi Biodiversity Targets and 2050 Vision for Biodiversity, the 2030 Sustainable Development Goals, the Paris Agreement on Climate Change, and several Environmental Conventions. On the other hand, more positive outcomes emerge from scenarios that account for transformative change and cross-sectoral approaches aligning production, consumption, and conservation of food, feed, fiber, energy, and water, as well as nature-friendly solutions to urban issues and to climate adaptation and mitigation.

Societal goals can be achieved in sustainable pathways through the rapid and improved deployment of existing policy instruments and new initiatives that more effectively enlist individual and collective action for transformative change. By its very nature, transformative change can expect opposition from those with interests vested in the status quo. If obstacles are overcome, commitment to mutually supportive international goals and targets, supporting actions by indigenous peoples and local communities at the local level, new frameworks for private sector investment and innovation, inclusive and adaptive governance approaches and arrangements, multi-sectoral planning and strategic policy mixes can help to transform the public and private sectors to achieve sustainability at the local, national and global levels.

The assessment clearly demonstrates that the loss of biodiversity is not only an environmental issue, but an economic, development, social, security, moral and ethical issue. Biodiversity has significant economic value, which should be recognized in national accounting systems; is central to development, through food, water and energy security; is a security issue in so-far-as loss of natural resources, especially in poor developing countries can lead to conflict; is an ethical issue because loss of biodiversity hurts the poorest of people who depend on it, further exacerbating an already inequitable world; and is a moral issue because we should not destroy it.

C. Some highlighted findings and their implications:

Since 1970, trends in agricultural production, fish harvest, bioenergy production and harvest of materials have increased substantially, along with the doubling of the world's population, a 4-fold increase in the global economy, and 10-fold increase in trade. Today, humans extract more from the Earth and produce more waste than ever before but do so unequally. Furthermore, the accelerated increase in demand for natural resources has been associated with the spatial decoupling of production from consumption, which has contributed to shifting the economic and environmental gains and losses of production and consumption to different regions, contributing to new economic opportunities, but also unequal impacts on biodiversity, ecosystems, and people. While environmental conditions have improved in some parts of the world, particularly among more developed countries, it has declined in other regions where exploitation of natural resources, commodity expansion, and industrial production have intensified. However, countries at different levels of development have experienced different levels of deterioration of nature for any given gain in economic growth.

C1. The continuing expansion of human activities is significantly altering the fabric of life of the planet:

-Global indicators of ecosystem extent and condition have shown a decrease by an average of 47 per cent of their estimated natural baselines, with many continuing to decline by at least 4 per cent per decade; terrestrial hotspots of endemic species are undergoing faster changes. Only around 25% of land is sufficiently unimpacted that ecological and evolutionary processes still operate with minimal human intervention, and global forest area is now approximately 68 per cent of the estimated pre-industrial level. While decline of forest has slowed down globally, it is still marked in the tropics. Particularly sensitive ecosystems include old-growth forests, insular ecosystems, and wetlands.

-The largest driver of biodiversity loss in terrestrial systems in the last several decades has been land use change and use, primarily the conversion of native habitats into the agricultural systems that have been needed to feed the world (Figure 1 shows the 5 direct drivers of the loss of biodiversity). The challenge is to transform our agricultural practices, many of which are unsustainable today, into ones that produce the food we need while protecting and conserving biodiversity, and in particular protecting the quantity and quality of our water resources. This means not expanding into pristine natural habitats, but using sustainable agroecological practices, less chemicals, and protecting our soils and pollinators. Too often fertilizers, pesticides and other chemicals run-off into our rivers, polluting them and many coastal regions around the world – a key issue for the quantity and quality of our water resources.

-While climate change has not been the dominant driver of the loss of biodiversity to date in most parts of the world, it is projected to become as important or more important than the other drivers in the coming decades. Since 1980, greenhouse gas emissions have doubled, raising average global temperatures by at least 0.7 degrees Celsius, changing precipitation patterns and increasing extreme weather events. Climate change is already adversely affecting genetic variability, species richness and populations, and ecosystems and it imposes a growing risk. Shifts in species distribution, changes in phenology, altered population dynamics and changes in the composition of species assemblage, or the structure and function of ecosystems, are evident and accelerating in marine, terrestrial and freshwater systems. Almost half (47 per cent) of threatened terrestrial mammals, excluding bats, and one quarter (23 per cent) of threatened birds may have already been negatively affected by climate change in at least part of their distribution (birds in North America and Europe suggest effects of climate change in their population trends since the 1980s). Ecosystems such as tundra and taiga and regions such as Greenland, previously little affected by people directly, are increasingly experiencing impacts of climate change. Large reductions and local extinctions of

populations are widespread. This indicates that many species are unable to cope locally with the rapid pace of climate change, through either evolutionary or behavioral processes, and that their continued existence will also depend on the extent to which they are able to disperse, to track suitable climatic conditions, and to preserve their capacity to evolve. Climate change shifts the boundaries of terrestrial biomes, in particular in boreal, subpolar and polar regions and semi-arid environments, and a warmer, drier climate will reduce productivity in many places. In contrast, rising atmospheric carbon dioxide concentrations can be beneficial for net primary productivity and enhance woody vegetation cover, especially in semi-arid regions. In turn loss of biodiversity can adversely affect climate, e.g., deforestation increases the atmospheric abundance of carbon dioxide, a key greenhouse gas.

-Therefore, it is essential that the issues of biodiversity loss and climate change are addressed together. This can be accomplished by transforming the way energy is produced and used. Fossil fuel energy can be replaced with cost-effective renewable energy sources, e.g., wind and solar power. There is also a need to improve the efficiency with which energy is used in transportation, buildings and industry. There are many nature-based approaches, e.g., large-scale reforestation and ecosystem restoration, that can be used to adapt to, or mitigate human-induced climate change. However, it is important to recognize that some of the suggested approaches to limit human-induced climate change, such as large-scale afforestation and bioenergy, will adversely affect biodiversity and food and water security, especially if native vegetation is replaced by monoculture bioenergy crops.

-Estimates that synthesizes trends in vertebrate populations, such as the Living Planet Index, show that such trends have declined rapidly since 1970, falling by 40% for terrestrial species, 84% for freshwater species and 35% for marine species.

-Currently, land degradation has reduced productivity in 23 per cent of the global terrestrial area, and between $235 billion and $577 billion (US dollars in 2015) in annual global crop output is at risk as a result of pollinator loss. The loss of coastal habitats and coral reefs reduces coastal protection, which increases the risk from floods and hurricanes to and property for the 100 million–300 million people living within coastal 100-year flood zones.

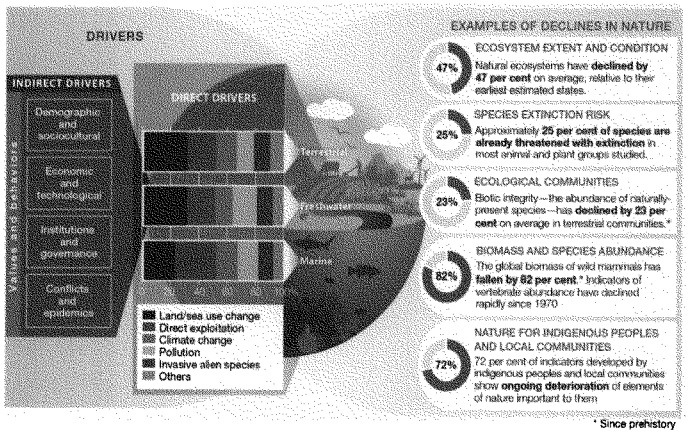

Figure 1: Drivers of the Loss of Biodiversity

-Inland waters and freshwater ecosystems show among the highest rates of decline. Only 13% of the wetland present in 1700 remained by 2000; recent losses have been even more rapid (0.8% per year from 1970 to 2008). Some regions are progressively reverting such decline through protection and restoration.

-Marine biodiversity is declining at unprecedented rates, with fishing exploitation having the largest negative impact in the past 50 years, while the impacts of climate change are accelerating. Over 40% of ocean area was strongly affected by multiple drivers in 2008, and 66% was experiencing increasing cumulative impacts in 2014. Only 3% of the ocean was described as free from human pressure in 2014. Seagrass meadows decreased in extent by over 10 per cent per decade from 1970-2000. Live coral cover on reefs has nearly halved in the past 150 years, the decline dramatically accelerating over the past 2-3 decades due to increased water temperature and ocean acidification interacting with and further exacerbating other drivers of loss. Severe impacts to ocean ecosystems are illustrated by estimation of 33% of fish stocks being classified as overexploited and greater than 55% of ocean area being subject to industrial fishing.

-Over 80 per cent of global wastewater is being discharged back into the environment without treatment, while 300–400 million tons of heavy metals, solvents, toxic sludge and other wastes from industrial facilities are dumped into the world's waters each year. Excessive or inappropriate application of fertilizer can lead to run off from fields and enter freshwater and coastal ecosystems, producing more than 400 hypoxic zones which affect a total area of more than 245,000 km^2 as early as 2008. Since 1980, plastic pollution in oceans has increased tenfold.

-Assessed evidence indicates that at least a quarter of the global land area is traditionally owned, managed, used or occupied by indigenous peoples alone, not accounting for a diverse array of local communities. A diverse array of local communities, including farmers, fishers, herders, hunters, ranchers and forest-users, manage significant areas under various property and access regimes. Indigenous areas in particular include approximately 35 per cent of the area that is formally protected, and approximately 35 per cent of all remaining terrestrial areas with very low human intervention. Nature is generally declining less rapidly in indigenous peoples' land than in other lands, but is nevertheless declining, as is the knowledge of how to manage it. The areas managed by indigenous peoples and local communities are under increasing pressure. For the first time, authors of the global assessment collected and synthetized over 470 local social-ecological indicators used to assess the status and trends of ecosystems and biodiversity. The analysis shows that among the local indicators developed and used by indigenous peoples and local communities, 72% show signs of decline, in many cases directly affecting local livelihoods and well-being.

-Several other analyses of status and trends in drivers of change and their impact on biodiversity and ecosystems are presented in the chapters of the report and the SPM.

C2. These changes, among others, are contributing to accelerated increase in species threatened with extinction, as well as undermining the achievements of both internationally-agreed biodiversity and sustainable development goals.

- Two distinct lines of evidence, the IUCN Red List criteria and model estimations based on analysis of habitat loss/deterioration and species assessments, point to similar levels of threat to biodiversity. An average of around 25% of species in assessed animal and plant groups and 10% of insect species (greater uncertainty) are threatened, suggesting that up to 1 million species already face extinction, some within decades, unless action is taken to reduce the intensity of drivers of biodiversity loss. These include around 500,000 species (of ~2.5 million) of animal and plant species that are not insects, and around 500,000 species (of ~5.5 million) of insect species, the latter is a more tentative estimate. Figure 2A shows global extinction risk in different species groups; figure 2B shows extinctions since 1500; and figure 2C shows declines in species survival since 1980.

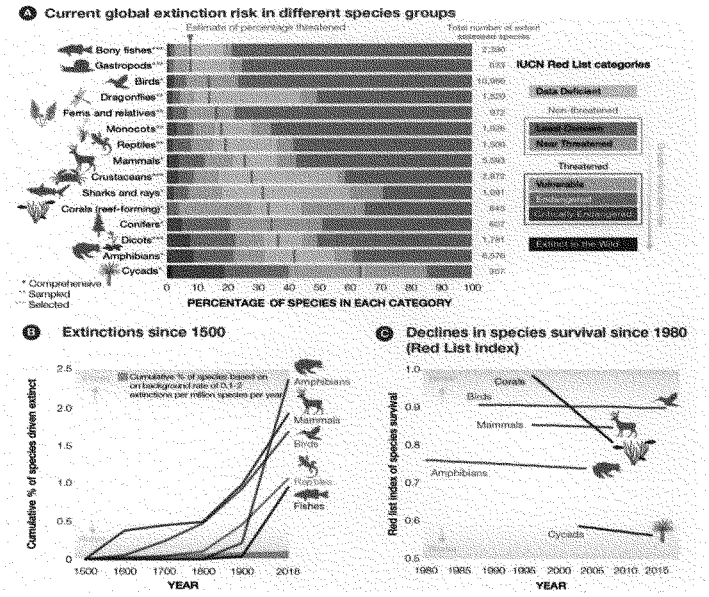

Figure 2. A substantial proportion of assessed species are threatened with extinction and overall trends are deteriorating, with extinction rates increasing sharply in the past century.

-It is important to highlight that, based on evidence, the report does not argue for or use the term 'mass extinction' to describe the current level of threat to biodiversity loss. The accepted definition of 'mass extinction' [used to describe the previous 5 extinction events] is the loss of 75% or more of all species. In the last several hundred years we have lost perhaps 1%-2% of species. Even if we lost all one million threatened species we would not be close to the threshold for calling it a mass extinction. Independent of the category used, the scientific evidence is clear about the scale and accelerated rate of extinction threats, which include for instance 40% of amphibians, 33% of reef-forming corals, and more than a third of all marine mammals.

-Worrying trends are also evident for local varieties and breeds of domesticated plants and animals. By 2016, 559 of the 6,190 domesticated breeds of mammals used for food and agriculture (over 9 per cent) had become extinct and at least 1,000 more are threatened. This loss of diversity, including genetic diversity, can pose serious future risks to local and global food security by undermining the resilience of many agricultural systems to threats such as pests, pathogens and climate change.

-The assessment also shows that globally 14 of the 18 categories of contributions of nature and ecosystem services that were assessed have declined, mostly regulating and non-material contributions[5] (Figure 3). Most contributions we derive from nature are not fully replaceable, while others are irreplaceable. Furthermore, the adverse impacts of climate change on biodiversity are

[5] Data supporting global trends and regional variations come from a systematic review of over 2,000 studies. Indicators were selected based on availability of global data, prior use in assessments and alignment with 18 categories.

projected to increase with increasing warming, creating further pressures on many contributions and ecosystem services of direct implication to human wellbeing.

Figure 3: Trends in Nature's Contributions to People

-These trends have affected progress towards internationally-agreed biodiversity targets. In particular, overall progress towards the Aichi Biodiversity Targets has been mixed. We have made good progress towards elements of just 4 of the 20 Aichi Targets. The strongest progress has been towards identifying/prioritizing invasive alien species (Target 9), increasing protected area coverage (Target 11), bringing the Nagoya Protocol on Access and Benefit Sharing into force, i.e., increasing the number of ratifying countries (Target 16), and developing national biodiversity strategy and action plans (Target 17). However, while protected areas now cover 14.9% of terrestrial and freshwater environments and 7.44% of the marine realm, they only partly cover areas of particular importance for biodiversity, and are not yet fully ecologically representative, well-connected, and effectively and equitably managed. While some species have been brought back from the brink of extinction (contributing towards Target 12 on preventing extinctions), species are moving towards extinction at an increasing rate overall for all taxonomic groups with quantified trends. Least progress has been made towards Target 10 (addressing drivers impacting coral reefs and other ecosystems vulnerable to climate change).

-There are also other areas of progress in the Aichi Biodiversity Targets. Although diversely across countries, there has been increasing awareness of biodiversity across sectors of society (Target 1). Advances in managing and sustainably harvesting aquatic living resources (Target 6) has also been noticeable, such as expanding certification programs, integrated coastal management, co-management, preventive management, marine conservation, among others. Advances are also noticeable in relation to managing agriculture, aquaculture and forestry sustainably (Target 7).

Land under conservation-oriented, organic agriculture is increasing along with landscape level planning for multi-functional landscapes. Forest certification, reduced impact logging, controlling illegal logging, real-time deforestation monitoring, incentives to local agriculture markets, payment for ecosystem services, and reduction in harmful subsidies are contributing to positive trends in some regions.

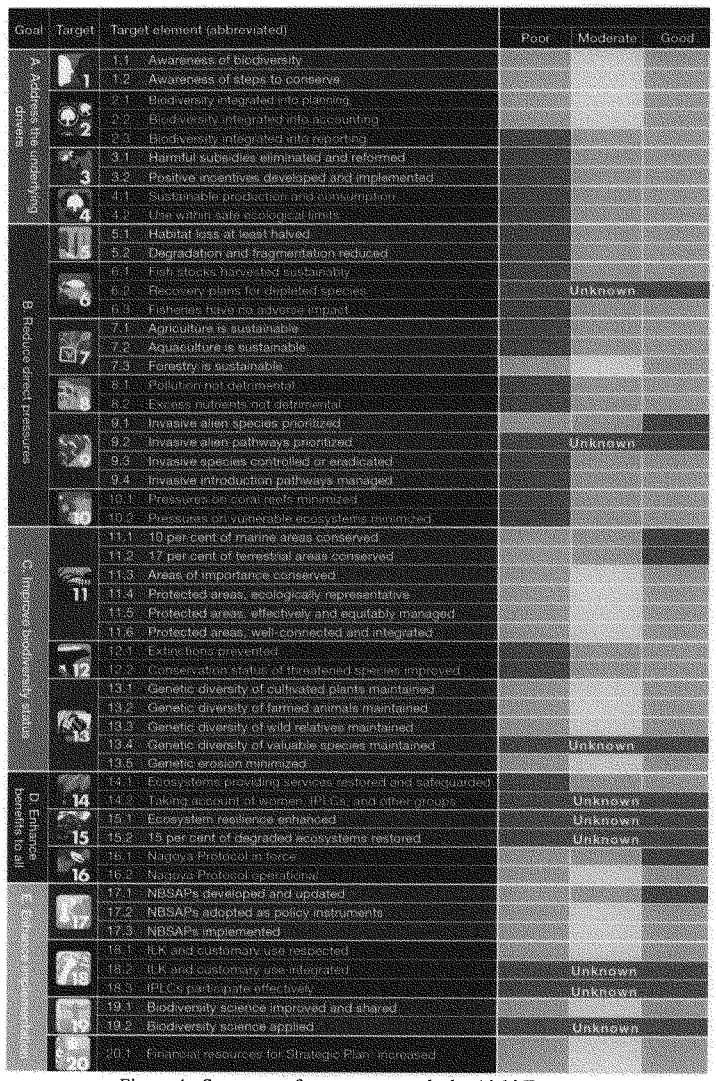

Figure 4: Summary of progress towards the Aichi Targets.

-Emerging evidence suggests that for Target 12, the extinction risk trends shown by the Red List Index for birds and mammals would have been worse in the absence of conservation, with at least six ungulate species. For Target 9, at least 107 highly threatened birds, mammals, and reptiles are estimated to have benefited from invasive mammal eradications on islands. One model estimate suggests that conservation investment during 1996-2008 reduced biodiversity loss (measured in terms of changes in extinction risk for mammals and bird) in 109 countries by 29% per country on average. These are encouraging signs.

-On the aggregate, however, more progress has been made in adopting and/or implementing policy responses and actions to conserve and use nature more sustainably (22 of 34 indicators show significant increases) than has been achieved in addressing the drivers of biodiversity loss (9 of 13 indicators show significantly worsening trends). As a result, the state of nature overall continues to decline (12 of 16 indicators show significantly worsening trends).

-The analyses carried out in the assessment made it clear that biodiversity, ecosystem functions and services directly underpin the achievement of several of the 2030 Sustainable Development Goals. Evidence (Figure 5) suggests that current negative trends in biodiversity and ecosystems will undermine progress towards 80 per cent (35 out of 44) of the assessed targets of goals related to poverty, hunger, health, water, cities, climate, oceans and land (Sustainable Development Goals 1, 2, 3, 6, 11, 13, 14, and 15). Important positive synergies between nature and goals on education, gender equality, reducing inequalities and promoting peace and justice (Sustainable Development Goals 4, 5, 10 and 16) were found. Land or resource tenure insecurity, as well as declines in nature, have greater impacts on women and girls, who are most often negatively impacted. Some pathways chosen to achieve the goals related to energy, economic growth, industry and infrastructure and sustainable consumption and production (Sustainable Development Goals 7, 8, 9 and 12), as well as targets related to poverty, food security and cities (Sustainable Development Goals 1, 2 and 11), could have substantial positive or negative impacts on nature and therefore on the achievement of other Sustainable Development Goals.

C3. Further evidence from the synthesis of future scenarios indicate that the negative trends in biodiversity and ecosystem functions are projected to continue or worsen to 2050 and beyond in response to indirect drivers as well as projected increase in direct drivers, such as climate change.

-Most scenarios project increasing supply and demand for material contributions with current market value (e.g., food, feed, timber and bioenergy), but decrease in regulating contributions from nature (e.g., regulation of water quantity, air, ocean acidification, habitat maintenance, pollination). These changes arise from continued human population growth, increasing purchasing power, and increasing per capita consumption, which influence the projected impacts of increasing land/and sea-use change, exploitation of organisms and climate change. Negative impacts arising from pollution and invasive alien species will likely exacerbate these trends.

-Business-as-usual is not an option if the world wants to conserve and sustainably use biodiversity. Business-as-usual will cause a continued loss of biodiversity. Scenarios that focus on economic growth and regional competition lead to an increase in material well-being, e.g., food production, but even greater loss of biodiversity. Plausible future scenarios that are more sustainable with low population growth coupled with sustainable and consumption practices, can slow, but not completely eliminate the future loss of biodiversity, in part, because climate is projected to warm in all scenarios.

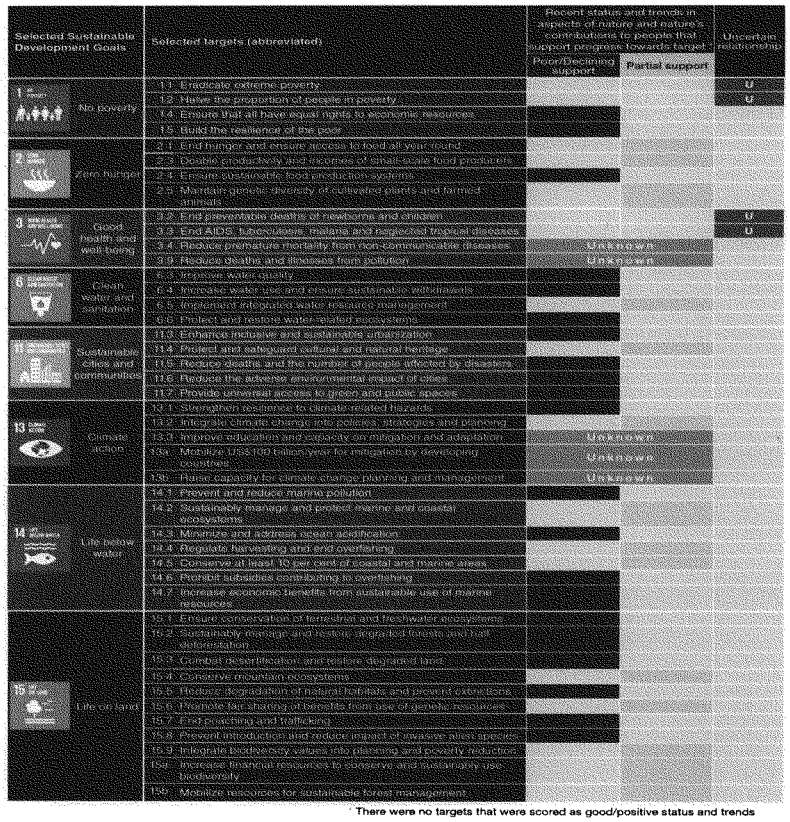

Figure 5: Summary of recent status of, and trends in, aspects of nature and nature's contributions to people that support progress towards achieving selected targets of the Sustainable Development

-Scenarios show that there are large projected regional differences in the patterns of future biodiversity and ecosystem functions and loss and changes in nature's contributions to people. Figure 6 shows a global-scale projection of changes in biodiversity and nature's material and regulating benefits, due to climate & land use change by 2050, while Figure 7 shows regional differences. While regions worldwide face further declines in biodiversity in future projections, tropical regions face combined risks of declines due to interactions of climate change, land-use change and fisheries exploitation. Marine and terrestrial biodiversity in boreal, subpolar and polar regions is projected to decline mostly because of warming, sea ice retreat and enhanced ocean acidification. The magnitude of impacts and the differences between regions are much greater in scenarios with rapid increases in consumption or human population than in scenarios based on sustainability. Acting immediately and simultaneously on multiple indirect and direct drivers has the potential to slow, halt and even reverse some aspects of biodiversity and ecosystem loss.

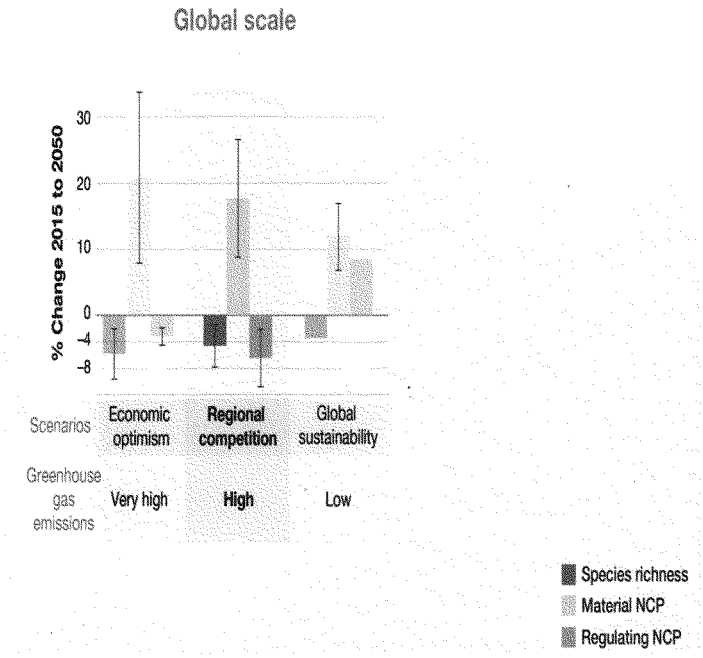

Figure 6: Global projections of impacts of land use and climate change on biodiversity and nature's material and regulating contributions to people between 2015 and 2050.

-Scenarios also show that while climate change is already having an impact on biodiversity and ecosystem functions, such impact is projected to intensify with the degree of global warming. For instance, a synthesis of many studies estimates the fraction of species at climate change related risk of extinction is 5% at 2°C warming, rising to 16% at 4.3°C warming. Projected climate change poses a growing risk owing to the accelerated pace of change and interactions with other direct drivers. Shifts in species distribution, changes in phenology, altered population dynamics and changes in the composition of species assemblage, or the structure and function of ecosystems, are evident and accelerating in marine, terrestrial and freshwater systems. Even for global warming from 1.5 to 2 degrees, the majority of terrestrial species ranges are projected to shrink profoundly. However, it should be noted that with the current and projected emissions of greenhouse gases, assuming the Paris agreement pledges are met, the world is on a pathway to an increase in global mean surface temperature of 3.0-3.5°C.

-Regarding the relative impact of climate change and land use, for terrestrial systems, most studies indicate that South America, Africa and parts of Asia will be much more significantly affected than other regions, especially in scenarios that are not based on sustainability objectives. That is due in part to regional climate change differences and in part to the fact that scenarios generally foresee the largest land use conversions to crops or bioenergy in those regions. Regions such as North America and Europe are expected to have low conversion to crops and continued reforestation.

-Our future oceans and our dependent livelihoods will strongly depend on the amount of greenhouse gases emitted today and in the coming decades. Mean sea surface temperature is projected to increase by +2.7°C in 2090-2099 as compared to 1990-1999 (or ca. 3.7°C above pre-industrial level) for the high emission scenario (RCP8.5, also considered as a "business as usual" scenario), whereas the warming is limited to +0.71°C for the more stringent RCP2.6 emission scenario (or ca. 1.7°C above pre-industrial level). At the regional scale, stronger warming occurs in the tropics, in the North Pacific and in the Arctic Ocean, with the sea surface warming more than +4°C at the end of the 21st century under RCP8.5. As global temperatures rise, so does the mean sea level due primarily to the thermal expansion of ocean water and by melting of glaciers, ice caps and ice sheets. Under the high emission scenario (RCP8.5), sea level rise (SLR) is projected to reach 52-131 cm by 2100 relative to year 2000. A broadly uniform decrease of the mean sea surface pH of -0.33 pH units by the 2090s relative to the 1990s is predicted under high emission scenario (RCP8.5), which will severely impact the growth of shells or skeletons of many calcifying marine organisms. Models also project decreasing global ocean oxygen due to climate change. The mechanisms at play are a reduction of oxygen solubility due to ocean warming and the combination of increased stratification and reduced ventilation that prevents the penetration of oxygen into the deep ocean. Deoxygenation will continue over the 21st century irrespective of the future scenario, with decreases of global O2 of -1.8% and -3.45% under RCP2.6 and RCP8.5, respectively, with a stronger drop for the North Pacific, the North Atlantic, and the Southern Ocean.

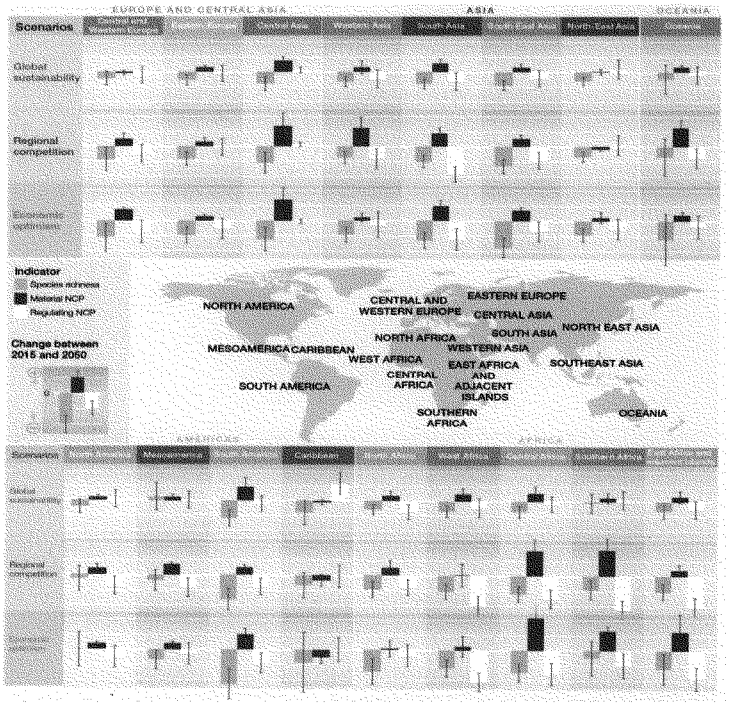

Figure 7: Projected changes in biodiversity and nature's material and regulating benefits, due to climate & land use change by 2050 by region

Future climate change will hence alter marine habitats and modify biogeochemical cycles, producing more hostile conditions and threatening vulnerable ecosystems and species with low adaptive capacity. By the end of the century, climate change is projected to decrease net primary production (by ca. 3.5% under the low greenhouse gas emissions scenario, RCP2.6 and up to 9% in the high emissions scenario, RCP8.5), and secondary production up to fish (by 3% to 23% under RCP2.6 and RCP8.5, respectively), as well as top predator. Fish populations and catch potential are projected to move poleward due to ocean warming with a mean latitudinal range shift of 15.5 km to 25.6 km per decade to 2050 (under RCP2.6 and RCP8.5, respectively), leading to high extirpation rates of biomass and local species extinctions in the tropics. However, that does not necessarily imply an increase in biodiversity in the polar seas, because of the rapid rate of sea ice retreat and the enhanced ocean acidification of cold waters in the Arctic and Southern Oceans. Along coastlines, the upsurge in extreme climatic events and sea level rise is expected to cause increased fragmentation and loss of habitats. Climate change is projected to become increasingly important as a direct driver of changes in nature and its contributions to people in the next decades. Scenarios project mostly adverse climate change effects on biodiversity and ecosystem functioning, which worsen with incremental global warming. They show that limiting global warming to well below 2°C plays a critical role in reducing adverse impacts on nature and its contributions to people. For example, coral reefs are particularly vulnerable to climate change and are projected to decline to 10-30 % of former cover at 1.5°C warming and to less than 1 % at 2°C warming.

C4. Considering the changes and challenges described above, the global assessment has carried out a nexus-based analyses of possible pathways to evaluate synergies and trade-offs for achieving different goals[6].

The global assessment makes it evident that the challenges posed by climate change, nature deterioration, and achieving a good quality of life for all are interconnected, and, they need to be addressed synergistically, from local to global levels. More importantly, the report recognizes the rich array of response, approaches, and instruments developed at all levels in response to social and environmental problems. As clearly noted in the report, building upon and improving existing approaches and initiatives can have immediate positive outcomes. Likewise, the deployment of existing policy instruments can have in itself a significant impact, along with the review and renewal of existing agreed environment-related international goals and targets based on the best available scientific knowledge. It also recognizes the need for sustaining and increasing in funding incentives for conservation, ecological restoration, and in support of sustainable use actions by all actors.–Along with existing options, the report calls for promoting new initiatives that evoke individual and corporate sustainability values, supporting and linking local actions, advance multi-sectoral planning and implementation, and supporting new frameworks for private sector investment and innovation.

The report also makes evident the importance of advancing governance approaches that are integrated, inclusive, informed, and adaptive in the face of new types of environmental risks and uncertainties, and possibilities for societal responses (Figure 8). Finally, it shows that it is equally important is to recognize the knowledge, innovations and practices, institutions and values of indigenous peoples and local communities, and their effective inclusion and participation in environmental governance. Such recognition and involvement enhance their quality of life, as well as nature conservation and sustainable use, relevant to broader society.

[6] The assessment report makes a distinction between the terms scenarios and pathways; while scenarios use narratives to explain outcomes generated by a model, pathways are possible trajectories toward the achievement of specific outcomes, for instance biodiversity conservation goals and targets in the context of the SDG.

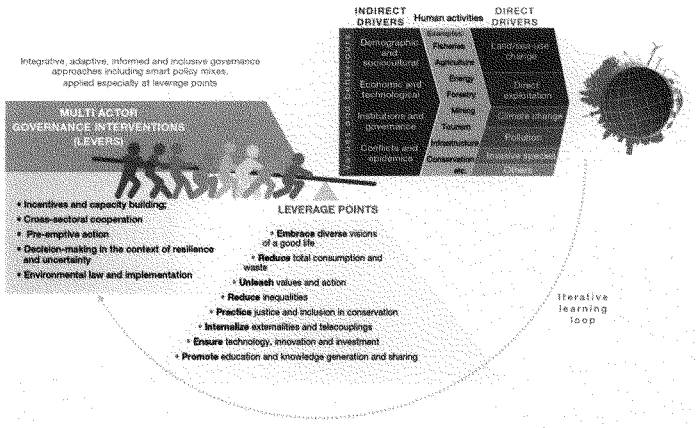

Figure 8. Transformative change in global sustainability pathways. Collaborative implementation of priority governance interventions (levers) targeting key points of intervention (leverage points) could enable transformative change from current trends towards more sustainable ones

→Cross-sectoral approaches are needed to promote sustainable pathways in food, materials, and energy production, conservation and restoration of freshwater, marine, and terrestrial environments, effective climate change mitigation and adaptation, and resilient urban systems and infrastructure.

-***Feeding humanity and enhancing the conservation and sustainable use of nature are complementary and closely interdependent goals.*** Pathways to sustainable food systems entail land use planning and sustainable management of both the supply/producer and the demand/consumer sides of food systems. These options include, depending on context, for instance integrated pest and nutrient management, organic agriculture, agroecological practices, soil and water conservation practices, conservation agriculture, agroforestry, silvopastoral systems, irrigation management, small or patch systems, and practices to improve animal welfare. These practices could be enhanced through well-structured regulations, incentives and subsidies, the removal of distorting subsidies, and--at landscape scales--by integrated landscape planning and watershed management. Ensuring the adaptive capacity of food production incorporates measures that conserve the diversity of genes, varieties, cultivars, breeds, landraces and species which also contribute to diversified, healthy and culturally-relevant nutrition. Some incentives and regulations may contribute to positive changes at both the production and consumption ends of supply chains, such as the creation, improvement and implementation of voluntary standards, certification and supply-chain agreements (e.g., the Soy Moratorium) and the reduction of harmful subsidies.

-***Expanding and effectively managing the current network of protected areas,*** *including terrestrial, freshwater and marine areas, is important for safeguarding biodiversity, particularly in the context of climate change.* This include implementing existing and developing new mechanisms for conserving areas. This suggests that strengthening advances in area-based conservation entail planning ecologically representative networks of interconnected protected areas to cover key biodiversity areas and managing trade-offs between societal objectives that represent diverse worldviews and multiple values of nature. Other important measures include enhancing monitoring and enforcement systems, managing biodiversity-rich land and sea beyond protected areas, addressing property rights conflicts and protecting environmental legal frameworks against

the pressure of powerful interest groups, building capacity and enhancing stakeholder collaboration, involving diverse stakeholders as well as indigenous peoples and local communities to establish and manage protected areas using instruments such as landscape-scale and seascape-scale participatory scenarios and spatial planning, including transboundary conservation planning. Implementation beyond protected areas includes combating wildlife and timber trafficking through effective enforcement and ensuring the legality and sustainability of trade in wildlife.

-Sustaining and conserving fisheries and marine species and ecosystems through integrated management on land, in freshwater and in the oceans. Multilevel coordination across stakeholders, accountability throughout the supply chain. It also entails policy action to apply sustainable ecosystem approaches to fisheries management, spatial planning (including the implementation and expansion of marine protected areas) and, more broadly, to address drivers such as climate change, pollution. Scenarios show that pathways to sustainable fisheries entail conserving, restoring and sustainably using marine ecosystems, rebuilding overfished stocks (including through targeted limits on catch or fishing efforts and moratoria), reducing pollution (including plastics), managing destructive extractive activities, eliminating harmful subsidies and illegal, unreported and unregulated fishing, adapting fisheries ma g the environmental impact of Aquaculture.

-Sustaining freshwater in the context of climate change, rising demand for water extraction and increased levels of pollution involves both cross-sectoral and sector-specific interventions that improve water use efficiency, increase storage, reduce sources of pollution, improve water quality and minimize disruption and foster restoration of natural habitats and flow regimes. Promising interventions include practicing integrated water resource management and landscape planning across scales; protecting wetland biodiversity areas; guiding and limiting the expansion of unsustainable agriculture and mining; slowing and reversing de-vegetation of catchments; and mainstreaming practices that reduce erosion, sedimentation and pollution run-off and minimize the negative impact of dams. Sector-specific interventions include improved water-use efficiency techniques (including in agriculture, mining and energy), decentralized (for example, household-based) rainwater collection, integrated management (e.g., 'conjunctive use') of surface and groundwater, locally developed water conservation techniques and water pricing and incentive programs (such as water accounts and payment for ecosystem services programs). With regard to watershed payment for ecosystem services programs, their effectiveness and efficiency can be enhanced by acknowledging multiple values in their design, implementation and evaluation and setting up impact evaluation systems.

-Land-based climate change mitigation activities can be effective and support conservation goals but can also can come with negative side effects for biodiversity and ecosystems, as well as for society. Integrated, context-specific, and inclusive planning, is important. The large-scale deployment of bioenergy plantations and afforestation of non-forest ecosystems can come with negative side effects for biodiversity and ecosystem functions. Nature-based solutions with safeguards are estimated to provide 37 per cent of climate change mitigation until 2030 needed to meet the 2°C Paris goal with likely co-benefits for biodiversity. Therefore, land-use actions are indispensable, in addition to strong actions to reduce greenhouse gas emissions from fossil fuel use and other industrial and agricultural activities. However, the large-scale deployment of intensive bioenergy plantations, including monocultures, replacing natural forests and subsistence farmlands, will likely have negative impacts on biodiversity and affect food and water security as well as local livelihoods, including by intensifying social conflict.

-Integrated city-specific and landscape-level planning, nature-based solutions and built infrastructure as well as responsible production and consumption can all contribute to sustainable and equitable cities and make a significant contribution to the overall climate change adaptation and mitigation effort. Urban planning approaches to promote sustainability include encouraging compact communities, designing nature-sensitive road networks and creating low impact (from an

emissions and land use perspective) infrastructure and transportation systems, including active, public and shared transport, which is already growing around the world. However, given that most urban growth between now and 2030 will take place in the Global South, major sustainability challenges include addressing, creatively and inclusively, the lack of basic infrastructure (water, sanitation and mobility), the absence of spatial planning and limited governance capacity and financing mechanisms. There are opportunities for complementarity of 'green' and 'gray' infrastructure, and sustainable technologies. Those challenges also offer opportunities for locally-developed innovation and experimentation, creating new economic opportunities.

D. Final considerations

The synthesis of evidence (indirect and direct drivers of change) indicates that moving away from current projections towards more sustainable pathways entails a broader process of evolution of the global financial and economic systems towards building a global sustainable economy. These include, *inter alia*, introducing and improving standards and systems, including relevant regulations, aimed at internalizing the external costs of production, extraction and consumption (such as pricing wasteful or polluting practices, including through penalties), promoting resource efficiency, circular and other economic models, voluntary environmental and social certification of market chains and incentives for sustainable practices and innovation. Actions that help to unleash, voluntarily, existing social values of responsibility in the form of individual, collective and organizational actions towards sustainability can have a powerful effect in shifting behavior and cultivating stewardship as a normal social practice.

There is also a need to eliminate agricultural, energy and transportation subsidies that are harmful to the environment, and to introduce short- term economic incentives to stimulate sustainable production and consumption. The economic system needs to evolve from one only focused on Gross Domestic Product (GDP), and be complemented by one that recognizes and incorporates the value of natural capital into economic accounting and incorporates the monetary and non-monetary values of biodiversity and its contributions to people into decision-making. Rarely do decision makers recognize the importance of nature's regulating services, i.e., the regulation of the climate, pollution, pollination, flood control, storm surges, and water purification - these all have significant non-market economic value and some of these services are irreplaceable. And of course, there is the wide range of social values associated with nature, which cannot be fully captured in economic terms.

There are, at all levels, many positive societal responses and successful examples. In many sectors, rapid transformative change is already happening. In the USA, for instance, individual awareness of the environmental impact of wasteful consumption is increasing, actions by individual, collectives, and the private sectors are seeking to develop innovative institutions, as well as new technologies that support sustainability goals. States, counties, rural communities, and cities are developing measures to improve resilience to issues such as flood, droughts, extreme weather events, wildfires, and extreme temperatures in the face of climate change. Consumers are contributing to promote more sustainable production systems and increasingly expecting corporate social and environmental responsibility to extend across the supply chain. Initiatives promoting sustainable production and resource management are expanding in sectors such as agriculture, forestry, and fisheries. New decentralized and low impact technologies for waste treatment, energy production, and water treatment are being developed and disseminated. The expansion of organic and conservation-focused food production is contributing to strengthening local economies and good environmental practices. In sum, transformative changes are already happening around the country and the world and can be further advanced through increasing connectivity of efforts, alignment of institutional arrangements, and incentives that recognize efforts at all levels. The global assessment sends a sobering, but optimistic message: Nature can be conserved, restored and used sustainably while simultaneously meeting other global (and local) societal goals, but urgent and concerted efforts fostering transformative change towards sustainability are called for.

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Because loss of biodiversity and climate change are environmental, development, economic, security, social, and equity issues they must be addressed together. This means that these issues are not just the domain of environment ministers, but of equal importance for ministries of agriculture, forestry, energy, finance, transportation, water and tourism. Therefore, Government departments are encouraged to work together to realize a sustainable world.

Sir Robert Tony Watson, CMG, FRS

My career has evolved from a Ph.D. student at QMC, London University; a post-doctoral fellow at University of California, Berkeley and University of Maryland, USA; a research scientist at the Jet Propulsion Laboratory, California Institute of Technology, USA; a Federal Government program manager/director at the US NASA; a scientific advisor in the Office of Science and Technology Policy (OSTP), White House, USA; a scientific advisor, manager and chief scientist at the World Bank; chief scientific advisor to the UK Department of Environment, Food and Rural Affairs; Sir Louis Matheson Fellow, Monash Sustainability Institute (MSI), Monash University, Australia, to my present part-time position as a Professor of Environmental Sciences and strategic director for the Tyndall Center at the University of East Anglia, UK. In parallel to my formal positions I have chaired, co-chaired or directed a number of national and international scientific, technical and economic assessments, including WMO/UNEP stratospheric ozone depletion assessments, Global Biodiversity Assessment, Millennium Ecosystem Assessment, UK National Ecosystem Assessment and its Follow-on, Intergovernmental Panel on Climate Change, the Intergovernmental Assessment of Agricultural Scientific and Technology for Development, and the Intergovernmental Science-Policy Platform for Biodiversity and Ecosystem Services. I have also been awarded a number of honours, including (2012 - Knights Bachelor – UK, and 2003 - "Companion of the Order of Saint Michael and Saint George" - UK); fellowships (2011 – Fellow of the Royal Society, UK), and awards, including 2014 – UN Champion of the World for Science and Innovation, 2010 - Asahi Glass Blue Planet Prize, 2008 – American Association for the Advancement of Science Award for International Scientific Cooperation, and I contributed to the 2007 - Nobel Peace Prize for the IPCC, which I chaired from 1997-2002.

Chairwoman JOHNSON. Thank you very much. Now we'll have Dr. Brauman.

TESTIMONY OF DR. KATE BRAUMAN, COORDINATING LEAD AUTHOR, IPBES GLOBAL ASSESSMENT, LEAD SCIENTIST, GLOBAL WATER INITIATIVE, UNIVERSITY OF MINNESOTA, INSTITUTE ON THE ENVIRONMENT

Dr. BRAUMAN. Madam Chair, Ranking Member Lucas, Members of the Committee, thank you for the opportunity to testify today. This testimony is based on the global assessment of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. As a coordinating lead author, I worked with a team of experts synthesizing existing published research on nature, and its very broad range of contributions to people. It is a big report. In short, people depend on nature. The deterioration of nature, species extinction, threatens the benefits that nature provides, from our basic food supply, to our very sense of selves. And most of these benefits, these ecosystem services, are not fully replaceable. Some of them are irreplaceable.

What do I mean by ecosystem services? Many of the material goods on which we depend, including food, bioenergy, medicines, other materials, come directly from nature. In addition, nature underlies the production of those tangible goods, and, indeed, our very life support systems on Earth. Nature plays a critical role in cycling water, affecting climate, and protecting us from natural hazards.

Nature offers more than this, however. Also critical to human wellbeing are the intangible benefits that it provides. Nature inspires science, technology, and art. It affects our mental health, and it provides a sense of place. Here in Washington, each spring the cherry blossoms bring joy and a sense of international connection, not to mention tourist dollars. In Minnesota, where I've made my home, our 10,000 lakes, and our pride in the boundary waters, are part of our collective identity. Yet the Global Assessment establishes that nature is in decline, so most of those benefits are declining as well.

There are five main causes: Changes in land and sea use, overutilization of plants and animals, climate change, pollution, and invasive species. Land use change has been the most important to date, largely because of its scale. Over the past 50 years, raw timber harvest has increased by 45 percent, and the value of agricultural crop production has increased nearly threefold. Let there be no mistake, our transformation of nature has been critical for both human nutrition and livelihoods, but we also must be clear-eyed about the impact. We have transformed the globe.

Today, over one-third of the terrestrial land surface is used for cropping or livestock. Agriculture, alongside growing urban areas, and expanding infrastructure, has transformed forests, wetlands, and grasslands around the world. This has led to declines in many ecosystem services, particularly those that underpin the environmental processes, and those that provide intangible benefits. For example, when we drain farm fields, soils and plants can no longer hold water, and this could exacerbate flooding downstream. Some

of this we've seen in the Midwest over the past several months. Excess fertilizer causes toxic algal blooms, like the one that shut down Toledo's water system in 2014, and causes dead zones in the Gulf of Mexico.

These impacts are widespread and pervasive. In the Global Assessment, we evaluated 18 categories of nature's benefits. Globally, we find increases only in production of material goods, goods whose value we already recognize. The majority of nature's benefits are in decline, including processes affecting air, water, and climate, as well as non-tangible benefits, such as the diversity of life from which to learn. Overall, the expansion of food, feed, fiber, bioenergy, has occurred at the cost of many of these other benefits, and those burdens and benefits are often distributed unequally across space and time, and among different segments of society.

Agriculture is an example not just as a driver of environmental change, it's also threatened by these, particularly in the face of a changing planet. Healthy soils are the basis of everything we grow, yet land degradation has reduced productivity on 23 percent of global terrestrial area. Bees are critically important to more than 75 percent of global food crop types, including fruit, vegetables, and many cash crops, yet they are also in decline, putting at risk as much as 577 billion in annual global crop output. This signals a threat to our continued ability to grow food, and maintain productive agricultural systems.

In addition, extinction threatens both wild and domesticated food plants and animals, posing a serious risk to global food security. Wild food relatives represent critical reservoirs of genes and traits that may provide resilience against future climate change, pests, and pathogens. Yet by 2016, domestic breeds of mammals used for food and agriculture, close to 10 percent, are already extinct. Without soils, plants can be grown hydroponically. Coastal flooding can be managed by dykes and seawalls, but substitutes are frequently expensive, and they incur high future costs. They cannot be the entirety of our Plan B. Looking forward, we can promote solutions by working with nature, and those solutions exist. Continued research is necessary, but there is much that we can do today. Thank you.

[The prepared statement of Dr. Brauman follows:]

Selected findings from the IPBES Global Assessment on Biodiversity and Ecosystem Services
House Committee on Space, Science and Technology
Nature in Crisis: Biodiversity Loss and its Causes, June 4 2019

Dr. Kate Brauman, Coordinating Lead Author of the IPBES Global Assessment
Lead Scientist, Global Water Initiative
at the University of Minnesota Institute on the Environment

I would like to thank the House Committee on Science, Space and Technology for the opportunity to provide a testimony based on the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). This testimony complements that provided by Sir Robert Watson.

In response to the request of the Committee, this testimony addresses: 1) major findings of the IPBES report related to trends in ecosystems services and how they are affected by the drivers of biodiversity loss, 2) issues of biodiversity in agriculture and ecosystem service benefits provided by non-marine ecosystems, 3) potential solutions identified in the IPBES Global Assessment, and 4) research gaps related to ecosystem services.

1) Trends in ecosystems services and how they are affected by the drivers of biodiversity loss

Since 1970, trends in agricultural production, fish harvest, bioenergy production and harvest of materials have increased, but 14 of the 18 categories of contributions of nature that were assessed, mostly regulating and non-material contributions, have declined. The value of agricultural crop production ($2.6 trillion in 2016) has increased approximately threefold since 1970, and raw timber harvest has increased by 45 per cent, reaching some 4 billion cubic meters in 2017, with the forestry industry providing about 13.2 million jobs. However, indicators of regulating contributions, such as soil organic carbon and pollinator diversity, have declined, indicating that gains in material contributions are often not sustainable. Currently, land degradation has reduced productivity in 23 per cent of the global terrestrial area, and between $235 billion and $577 billion in annual global crop output is at risk as a result of pollinator loss. Moreover, loss of coastal habitats and coral reefs reduces coastal protection, which increases the risk from floods and hurricanes to life and property for the 100 million–300 million people living within coastal 100-year flood zones.

Nature's contributions to people are often distributed unequally across space and time and among different segments of society. There are often trade-offs in the production and use of nature's contributions. Benefits and burdens associated with co-production and use of nature's contributions are distributed and experienced differently among social groups, countries and regions. Giving priority to one of nature's contributions to people, such as food production, can result in ecological changes that reduce other contributions. Some of these changes may benefit some people at the expense of others, particularly the most vulnerable, as may changes in technological and institutional arrangements. For example, although food production today is sufficient to satisfy global needs, approximately 11 per cent of the world's population is undernourished, and diet-related disease drives 20 per cent of premature mortality, related both to undernourishment and to obesity. The great expansion in the production of food, feed, fiber and bioenergy has occurred at the cost of many other contributions of nature to quality of life, including regulation of air and water quality, climate regulation and habitat provision. Synergies also exist, such as sustainable agricultural practices that enhance soil quality, thereby improving productivity and other ecosystem functions and services such as carbon sequestration and water quality regulation.

Figure 1. Global trends in the capacity of nature to sustain contributions to good quality of life from 1970 to the present, which show a decline for 14 of the 18 categories of nature's contributions to people analyzed. Data supporting global trends and regional variations come from a systematic review of over 2,000 studies {2.3.5.1}. Indicators were selected on the basis of availability of global data, prior use in assessments and alignment with 18 categories. For many categories of nature's contributions, two indicators are included that show different aspects of nature's capacity to contribute to human well-being within that category. Indicators are defined so that an increase in the indicator is associated with an improvement in nature's contributions.

The rate of global change in nature during the past 50 years and the related impact on ecosystem services is unprecedented in human history. The direct drivers of change in nature with the largest global impact have been (starting with those with most impact): changes in land and sea use; direct exploitation of organisms; climate change; pollution; and invasion of alien species. Those five direct drivers result from an array of underlying causes – the indirect drivers of change – which are in turn underpinned by societal values and behaviors that include production and consumption patterns, human population dynamics and trends, trade, technological innovations and local through global governance. The rate of change in the direct and indirect drivers differs among regions and countries.

The average per capita consumption of materials (e.g., plants, animals, fossil fuels, ores, construction material) rose by 15 per cent since 1980. This activity has generated unprecedented impacts: since 1980, greenhouse gas emissions doubled, raising average global temperatures by at least 0.7 degrees Celsius, while plastic pollution in oceans has increased tenfold. Over 80 per cent of global wastewater is being discharged back into the environment without treatment, while 300–400 million tons of heavy metals, solvents, toxic sludge and other wastes from industrial facilities are dumped into the world's waters each year. Excessive or inappropriate application of fertilizer can lead to run off from fields and enter freshwater and coastal ecosystems, producing more than 400 hypoxic zones which affect a total area of more than 245,000 km^2 as early as 2008.

2) Biodiversity in agriculture and ecosystem services provided by non-marine ecosystems
Nature plays a critical role in providing food and feed, energy, medicines and genetic resources and a variety of materials fundamental for people's physical well-being and for maintaining culture. For example, more than 2 billion people rely on wood fuel to meet their primary energy needs, an estimated 4 billion people rely primarily on natural medicines for their health care and some 70 per cent of drugs used for cancer are natural or are synthetic products inspired by nature. Nature, through its ecological and evolutionary processes, sustains the quality of the air, fresh water and soils on which humanity depends, distributes fresh water, regulates the climate, provides pollination and pest control and reduces the impact of natural hazards. For example, more than 75 per cent of global food crop types, including fruits and vegetables and some of the most important cash crops such as coffee, cocoa and almonds, rely on animal pollination. Marine and terrestrial ecosystems are the sole sinks for anthropogenic carbon emissions, with a gross sequestration of 5.6 gigatons of carbon per year (the equivalent of some 60 per cent of global anthropogenic emissions). Nature underpins all dimensions of human health and contributes to non-material aspects of quality of life – inspiration and learning, physical and psychological experiences, and supporting identities – that are central to quality of life and cultural integrity, even if their aggregated value is difficult to quantify. Most of nature's contributions are co-produced with people, but while anthropogenic assets – knowledge and institutions, technology infrastructure and financial capital – can enhance or partially replace some of those contributions, some are irreplaceable. The diversity of nature maintains humanity's ability to choose alternatives in the face of an uncertain future.

Biodiversity is particularly important for agriculture. Globally, local varieties and breeds of domesticated plants and animals are disappearing. This loss of diversity, including genetic diversity, poses a serious risk to global food security by undermining the resilience of many agricultural systems to threats such as pests, pathogens and climate change. Fewer and fewer varieties and breeds of plants and animals are being cultivated, raised, traded and maintained around the world, despite many local efforts, which include those by indigenous peoples and local communities. By 2016, 559 of the 6,190 domesticated breeds of mammals used for food and agriculture (over 9 per cent) had become extinct and at least 1,000 more are threatened. In addition, many crop wild relatives that are important for long-term food security lack effective

protection, and the conservation status of wild relatives of domesticated mammals and birds is worsening. Reductions in the diversity of cultivated crops, crop wild relatives and domesticated breeds mean that agroecosystems are less resilient against future climate change, pests and pathogens.

Many of nature's contributions to people are essential for human health and their decline thus threatens a good quality of life. Nature provides a broad diversity of nutritious foods, medicines and clean water, can help to regulate climate, reduce levels of certain air pollutants, and improve mental and physical health through exposure to natural areas, among other contributions. Nature is the origin of most infectious diseases (negative impact), but also the source of medicines and antibiotics for treatment (positive contribution). Zoonotic diseases are significant threats to human health, with vector-borne diseases accounting for approximately 17 per cent of all infectious diseases and causing an estimated 700,000 deaths globally per annum. The deterioration of biodiversity and ecosystem functions, and the consequent disruption of benefits to people, has both direct and indirect implications for public health. Emerging infectious diseases in wildlife, domestic animals, plants or people can be exacerbated by human activities such as land clearing and habitat fragmentation or the overuse of antibiotics driving rapid evolution of antibiotic resistance in many bacterial pathogens. The deterioration of nature and consequent disruption of benefits to people has both direct and indirect implications for public health and can exacerbate existing inequalities in access to health care or healthy diets. Shifting diets towards a diversity of foods, including fish, fruit, nuts and vegetables, significantly reduces the risk of certain preventable non-communicable diseases, which are currently responsible for 20% of premature mortality globally.

Most of nature's contributions are not fully replaceable, yet some contributions of nature are irreplaceable. Loss of diversity, such as phylogenetic and functional diversity, can permanently reduce future options, such as wild species that might be domesticated as new crops and be used for genetic improvement. People have created substitutes for some other contributions of nature, but many of them are imperfect or financially prohibitive. For example, high-quality drinking water can be achieved either through ecosystems that filter pollutants or through human-engineered water treatment facilities. Similarly, coastal flooding from storm surges can be reduced either by coastal mangroves or by dikes and sea walls. In both cases, however, built infrastructure can be extremely expensive, incur high future costs and fail to provide synergistic benefits such as nursery habitats for edible fish or recreational opportunities. More generally, human-made replacements often do not provide the full range of benefits provided by nature.

3) Potential solutions.

Nature and the benefits it provides can be conserved, restored and used sustainably while simultaneously meeting other global societal goals. Feeding humanity and enhancing the conservation and sustainable use of nature are complementary and closely interdependent goals that can be advanced through sustainable agricultural, aquacultural and livestock systems, the safeguarding of native species, varieties, breeds and habitats, and ecological restoration. Specific actions include promoting sustainable agricultural practices, such as good agricultural and agroecological practices, among others, multifunctional landscape planning and cross-sectoral integrated management, that support the conservation of genetic diversity and associated agricultural biodiversity. Further actions to simultaneously achieve food security, biodiversity protection and sustainable use are context-appropriate climate change mitigation and adaptation, incorporating knowledge from various systems, including the sciences and sustainable indigenous and local practices, avoiding food waste, empowering producers and consumers to transform supply chains and facilitating sustainable and healthy dietary choices. As part of integrated landscape planning and management, prompt ecological restoration emphasizing the use of native

species can offset current degradation and save many endangered species but is less effective if delayed.

Conservation actions, including protected areas, efforts to manage unsustainable use and address illegal taking and trade of species, translocations and invasive species eradications, among others, have been successful in preventing the extinction of some species. Although still few and spatially localized, documented examples show that with prompt and appropriate action, it is possible to reduce human- induced extinction rates. There are, however, few other counterfactual studies assessing how trends in the state of nature or pressures upon nature would have been different in the absence of conservation efforts.

Five main interventions ("levers") can generate transformative change by tackling the underlying indirect drivers of nature deterioration: (1) incentives and capacity-building; (2) cross-sectoral cooperation; (3) pre-emptive action; (4) decision-making in the context of resilience and uncertainty; and (5) environmental law and implementation. Employing these levers involves the following, in turn: (1) developing incentives and widespread capacity for environmental responsibility and eliminating perverse incentives; (2) reforming sectoral and segmented decision-making to promote integration across sectors and jurisdictions; (3) taking pre-emptive and precautionary actions in regulatory and management institutions and businesses to avoid, mitigate and remedy the deterioration of nature, and monitoring their outcomes; (4) managing for resilient social and ecological systems in the face of uncertainty and complexity to deliver decisions that are robust in a wide range of scenarios; and (5) strengthening environmental laws and policies and their implementation, and the rule of law more generally. All five levers may require new resources, particularly in low-capacity contexts such as in many developing countries.

Transformations towards sustainability are more likely when efforts are directed at the following key leverage points, where efforts yield exceptionally large effects: (1) visions of a good life; (2) total consumption and waste; (3) values and action; (4) inequalities; (5) justice and inclusion in conservation; (6) externalities and telecouplings; (7) technology, innovation and investment; and (8) education and knowledge generation and sharing. Specifically, the following changes are mutually reinforcing: (1) enabling visions of a good quality of life that do not entail ever-increasing material consumption; (2) lowering total consumption and waste, including by addressing both population growth and per capita consumption differently in different contexts; (3) unleashing existing widely held values of responsibility to effect new social norms for sustainability, especially by extending notions of responsibility to include impacts associated with consumption; (4) addressing inequalities, especially regarding income and gender, which undermine capacity for sustainability; (5) ensuring inclusive decision-making, fair and equitable sharing of benefits arising from the use of and adherence to human rights in conservation decisions; (6) accounting for nature deterioration from local economic activities and socioeconomic-environmental interactions over distances (telecouplings), including, for example, international trade; (7) ensuring environmentally friendly technological and social innovation, taking into account potential rebound effects and investment regimes; and (8) promoting education, knowledge generation and maintenance of different knowledge systems, including the sciences and indigenous and local knowledge regarding nature, conservation and its sustainable use.

Recognizing the knowledge, innovations and practices, institutions and values of indigenous peoples and local communities and their inclusion and participation in environmental governance often enhances their quality of life, as well as nature conservation, restoration and sustainable use, which is relevant to broader society. Governance, including customary institutions and management systems, and co-management regimes involving indigenous peoples and local

communities, can be an effective way to safeguard nature and its contributions to people, incorporating locally attuned management systems and indigenous and local knowledge. The positive contributions of indigenous peoples and local communities to sustainability can be facilitated through national recognition of land tenure, access and resource rights in accordance with national legislation, the application of free, prior and informed consent, and improved collaboration, fair and equitable sharing of benefits arising from the use, and co-management arrangements with local communities.

4) Research gaps in ecosystem services research

Since the Millennium Ecosystem Assessment was published in 2005, substantial data have been collected on biodiversity, ecosystems, ecosystem services and more generally on the co-production and impact of social, environmental, and climate change upon them. Despite this progress, however, large information gaps remain in assessing the status and trends of nature's contributions to people, and particularly their implications to the quality of life of different groups of people.

The extent of nature's contribution to good quality of life is not well understood for some of nature's contributions to people. The lack of understanding arises for several reasons. First, it is often hard to disentangle nature's contributions from other contributions. For example, though we have good data on status and trends of air quality across major cities in the world, how changes in vegetation impact air quality in cities is less well understood and is currently a frontier of scientific investigation. Second, understanding of key links between nature and impacts on good quality of life may be missing. For example, though we often have a good understanding of how changes in exposure affect disease incidence and impacts on human health, how changes in nature influence exposure is often complex and is poorly understood for some diseases. Exposure for vector-borne diseases depends on populations of vectors as well as how these vectors overlap with vulnerable populations of humans. Vector populations can depend on complex ecosystem interactions that give rise to unpredictable increases or decreases in populations as a function of anthropogenic induced changes to ecosystems. Exposure also depends on human behavior and public health measures designed to reduce the vulnerability of human populations to disease.

Even where the extent of nature's contribution to good quality of life is well understood, there is often a lack of systematic data collection, or systematic documentation, on which to base a comprehensive global assessment. Much of the literature on non-material contributions to people involves detailed case studies of specific groups. This literature provides a wealth of information but studies typically differ in focus and methodology, and there is uneven coverage across regions, which makes it difficult to combine results into a systematic global assessment. For most ecosystem services we lack systematic reporting on impacts of nature on good quality of life. Much of the natural science literature focuses on changes in ecosystems and biodiversity but does not report how these changes affects good quality of life. Much of the systematic data reporting on various aspects of good quality of life (such as income, livelihoods, health, and education) does not disentangle the impacts of nature on good quality of life from other impacts. It would be ideal to report quantitative measures of nature's contributions in terms readily understood by various decision-makers and the general public. While we have some measures of nature's contributions to people reported in monetary terms, health terms, or other measures related to good quality of life, we lack systematic indicators that can be reported in a variety of easily understood metrics for many of nature's contributions.

A general issue in doing a comprehensive global assessment is the existing fragmented state of knowledge with lack of integration between social and natural sciences, and between western science and ILK. This assessment has emphasized the importance of including multiple viewpoints

and sources of knowledge but this has not been matched with an ability to effectively integrate multiple sources of knowledge into a systematic assessment. Different world views are hard to integrate in substantive ways. Doing so will require increased dialog across communities and agreement on how to be more systematic in knowledge generation and data collection.

Measuring trends in nature's contributions requires having a time series of data measured in a consistent fashion. Consistent time series data exists for some aspects of some of nature's contributions but is lacking for many aspects of most of nature's contributions. For some environmental measures it is now possible to get consistent global data via remote sensing. However, many remote sensing data series begin with the satellite era, so that many of these time series are of fairly short duration. In contrast, measures of impact on good quality of life often require direct observation or survey work. Time series data exists for income, health and other measures of human well-being but typically does not report on the impact that nature has on good quality of life.

Dr. Kate Brauman

Kate Brauman is the lead scientist for Global Water Initiative at IonE, where she studies the coupled interaction of land-use change and water resources. Kate brings together the study of hydrology and plant-water relations with economics and policy to explore the effects of land cover on water delivery to downstream users. She is focused on hydrologic ecosystem services and global water availability and use, particularly by agriculture.

Kate received her doctorate from the Interdisciplinary Program in Environment and Resources at Stanford University, where she designed and led a project on the Big Island of Hawai'i quantifying the effects of pasture and forest on groundwater recharge and calculating the associated costs of water extraction.

Chairwoman JOHNSON. Dr. Porter.

TESTIMONY OF DR. JAMES PORTER,
JOSIAH MEIGS PROFESSOR OF ECOLOGY, EMERITUS,
ODUM SCHOOL OF ECOLOGY, UNIVERSITY OF GEORGIA

Dr. PORTER. And if we could have the first slide, please? Thank you very much, Madam—Chairwoman Johnson, Ranking Member Lucas, and Members of the Committee for inviting me here. I'll make my introductory comments with a clip of film from *Chasing Coral* playing in the background.

Coral reefs cover only 1 percent of the Earth's surface, and yet within that 1 percent are 25 percent of all marine plant and animal species. Coral reef generate $9.9 trillion per year in economic benefit for 500 million people that depend on them exclusively for their source of income, and for their protein. In addition to that, coral reefs generate $24 billion a year to Florida and Hawaii alone. And across coral reefs have generated amazing new drugs from the sea. A new drug from last year that reduces the risk of heart attack in elderly Americans, another drug that cures prostate cancer, and a third drug that is more powerful in killing the HIV virus than AZT. It is an amazing cornucopia.

All of the ills that have been mentioned for other ecosystems apply to coral reefs, including exploitation, and also pollution of plastics, and invasive species, such as the lionfish, which is from the Indo-Pacific, is now in the Caribbean. But the key driver of diversity loss in the oceans is, in fact, climate change. The reason for this is that corals are only 2 degrees away from the high temperatures that kill them. The irony is that, of the warming heat that has been generated in the last 50 years, only 7 percent of that is in the air. The remaining 93 percent of the heat is in the oceans. The oceans have absorbed this heat. We know this because we have indeed measured it. If the oceans had not been the Earth's punching bag to take this heat, then the average temperature outside this room today would be 122 degrees Fahrenheit. That is the physics of what we are dealing with.

I'm going to show you two examples from coral reefs. First, from Jamaica, this is a picture from 1976. This is what this reef looks like today. You have a right to ask, is that from the same place? I direct your attention to the boulder coral, with the distinctive eyespot, the lower right hand corner. There it was before, here it is again. We are in the same place. Now let us look for—closer to home, the Florida Keys. In 1994, a coral reef off Key West. There it was before, and in 2004, the corals are going, going, gone. It does not matter what place in the Florida Keys you go to, you get the same result.

Seventy-five percent of all reefs in the Florida Keys have fewer species now than they did before. In the upper right hand coral—some coral species have gone extinct, and the branching and elk horn corals that you see in the lower right, once the commonest corals in the Caribbean, are now on the critically endangered species list. This Committee deals with species, but, on reefs, it's not just at the species level. The genus, the family, the order, the class, all are at risk. A recent paper in *Science* shows that 85 percent of the time that these higher taxa appeared on this planet, they did

so on coral reefs, making them evolution's cradle, and also their museum. The cradle to evolve new forms, the museum to retain them.

An example is from the class sponges. They have the miracle that they can secrete their skeleton either out of calcium, like you and me, or out of silicon glass. The last time a class of organisms on this planet went extinct was 500 million years ago, and within the next 50 years we can eliminate this class. We are not only trimming the leaves, the species, we are trimming the branches, the trunk, and the roots of the life on this planet.

Climate change is the cause, and we are worried that in 2040 we are going to see a loss of coral reefs worldwide as they bleach, and turn white, and die. But, if we were able to reduce the amount of greenhouse gases through all the kinds of technology's imaginable, we could take that 2040 away, and buy coral reefs at least 100 years in which they might be able to evolve thermal tolerance.

Seventy-five percent of the living coral in Florida has died in the last 10 years. Sixty-six percent of all corals on the Barrier Reef died in the last 2 years from climate change. This Committee is about life on Earth. We can save the biodiversity of the planet, but we must begin now. Thank you for coming.

[The prepared statement of Dr. Porter follows:]

Congressional Testimony on the IPBES

(Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services)

Assessment of Global Biodiversity Loss

Dr. James W. Porter
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University of Georgia
Athens, GA 20602
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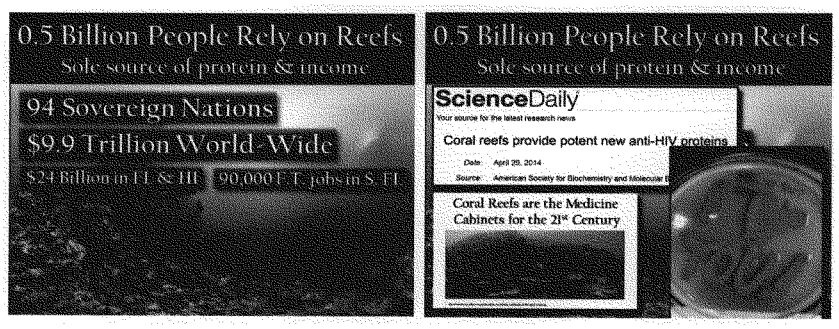
U.S. House of Representatives *Committee on Science, Space, & Technology*
Rayburn House Office Building; Room 2321
Tuesday-4-June-2019; 10:00 AM
Congresswoman, Eddie Bernice Johnson, (Texas) Chair

This hearing has been called to addresses the continuation of diverse life on Earth and the integrity of the life-support systems that diverse ecosystems provide to everyone. The current IPBES assessment suggests that of the estimated 8.7 million species on Earth, 1 million are facing extinction. In addition, the magnitude and pace of these extinctions is likely to accelerate unless we put in place sweeping and sustained actions to prevent these catastrophic losses.

In this testimony, I will show that the global losses detailed in the IPBES Report are already occurring on coral reefs. Further, I will present evidence demonstrating that the risks outlined in their assessment will, almost inevitably, increase for coral reefs in the very near future.

Although coral reefs are tropical shallow-water marine habitats and cover less than 1% of the planet, they have an outsized importance to both human beings and the natural world.



Coral reefs generate $9.9 trillion U.S.D. annually. A half billion people rely on them for their protein and as a source of income.

The following gives a thumbnail sketch of the importance of coral reefs to humankind:

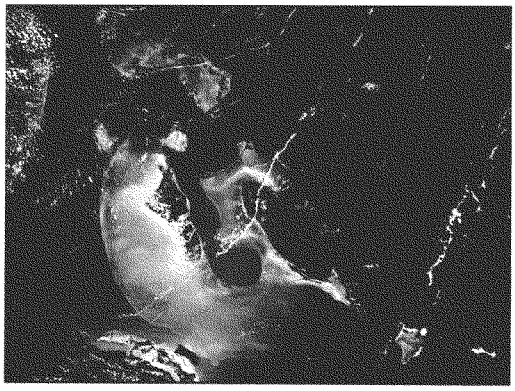
- 94 of the world's sovereign nations (roughly half of all countries) have coral reefs within their territorial boundaries.
- Most of these are developing countries desperately in need of the goods and services that coral reefs provide.
- 500 million people are dependent on coral reefs as their primary source of protein and income.
- Coral reefs generate $9.9 trillion U.S.D. / yr. (roughly the GDP of Switzerland).
- Coral reefs generate $29.8 billion/yr. in Hawaii and Florida.
- On the Great Barrier Reef, 90,000 full-time jobs are directly dependent on coral reefs.
- Coral reefs have proven to be a marine pharmacopeia, yielding new drugs that reduce the risk of heart attacks in older Americans, cure certain kinds of cancer, and that kill the A.I.D.S. virus more effectively than AZT.

In addition to their importance to human society, coral reefs are also of outsized importance to the history of life on Earth:

- Coral reefs are the oldest, most productive, and most biologically diverse of all marine communities.
- Coral reefs are the only living things that can be seen from outer space.
- 25% of all described marine species of plants and animals live exclusively on coral reefs.
- With increased taxonomic studies, that percentage would rise dramatically.
- However, with the predicted near-term extinction of coral reefs world-wide, we may never know that number precisely. In this respect, Dr. E.O. Wilson's comment seems especially apropos:

Most species will probably be described from a single museum specimen, long after the species has gone extinct.

E.O. Wilson, Harvard University



- Coral reefs are the most productive of all marine communities, generating close to 2,000 dry grams-carbon / m^2 / yr.
- Due to their biological diversity, especially at higher taxonomic levels, coral reefs are by far the most diverse environments on Earth. For instance, while tropical rainforests harbor only 8 animal phyla, coral reefs sport 30.
- Most importantly, recent studies of the history of life on Earth show that 85% of the time that a new Family, Order, Class, or Phylum appears on Earth, it does so first on coral reefs. This makes coral reefs both a *Cradle* of evolution for radically new life forms and a *Museum* for their ability to retain species that evolve there.
- The destruction of coral reefs therefore does not just threaten global species diversity, but also the fundamental ability of life to generate new life.
- A specific example of this comes from the marine sponges (Phylum Porifera). Class Sclerospongiae, one of the 5 classes of sponges. It has the unique ability to form its skeleton out of either limestone (calcium) or glass (silicone).
- This Class is exclusively shallow-water, tropical marine.
- Although the last Class of organisms (in any phylum) went extinct more than 500 million years ago, with the destruction of coral reefs, we could lose this Class within the next 50 years.

Unit: Porifera | **5 Class Sclerospongiae**

Class Sclerospongiae

These sponges have a skeleton constructed from calcium carbonate, silica and spongin* . They have a thin, living layer covering a massive underlying skeleton of aragonite-silica and spongin which support the cells.

These are the coralline sponges, which are mostly known from fossils. There are a few modern species, e.g. *Sclerospongia* sp., which are only found on coral reefs in the West Indies and Pacific, where they contribute to the structure of the reefs. There are no specimens on display .

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3 Class Hexactinellida
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6 Key features
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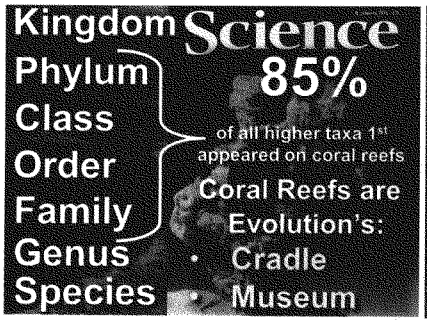
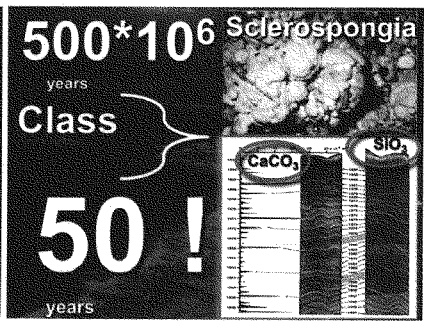
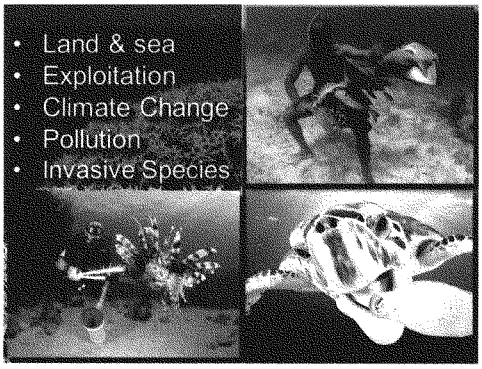


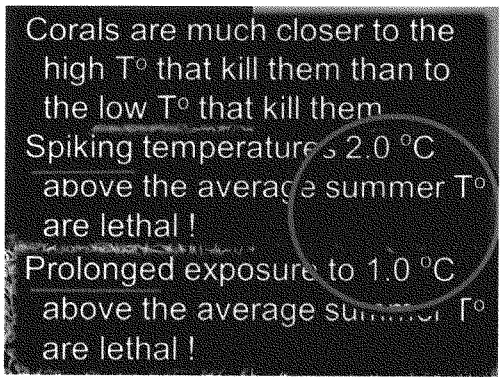


All of the factors listed by the IPBES as threats to the survival of terrestrial species world-wide also pertain, in varying degrees, to coral reef species.

- The destruction of coastal zone habitats (including mangroves and sea grass beds) occurs by rampant shore-line development.
- Overfishing on coral reefs, especially of large fish and top predators, such as sharks, occurs in many tropical countries.
- Pollution, both:
    - Large and small plastic particles on beaches and in many central oceanic gyres.
    - Coastal-zone eutrophication driven by waste-water from coastal communities and nearby agricultural lands (especially fertilizer-intensive sugar cane fields).
- Invasive species, such as the Indo-Pacific lion fish that were released into the tropical waters of South Florida are now found everywhere throughout the Caribbean.

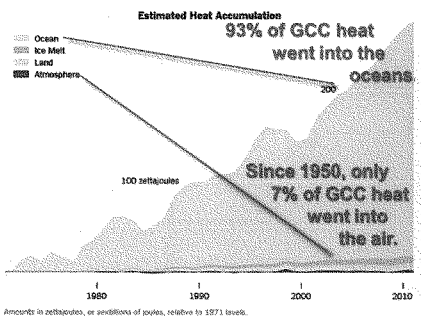


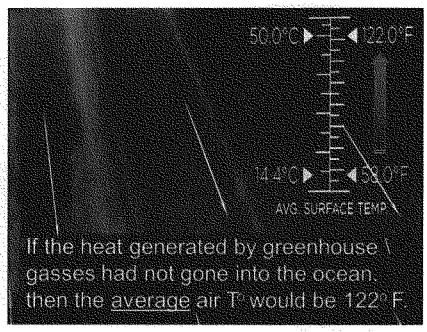
By far the biggest threat to coral reefs, however, comes not from these ancillary stressors, but from rising ocean temperatures. Corals already live close to their thermal tolerance limits. The addition of just 2° C will kill them.



Due to burning fossil fuels (coal, oil, and natural gas), global temperatures are rising rapidly, especially in the oceans. The reason for this can be summarized as follows:

- 93% of the heat generated by green-house gases is "stored" in the ocean, not in the air.
- This is why water temperatures have risen so quickly.
- If it weren't for the oceans' ability to absorb greenhouse-gas generated global-warming, the average temperature of our planet would be 122°F.
- The oceans are 'saving' us (temporarily), but at an immediate cost to coral reefs.



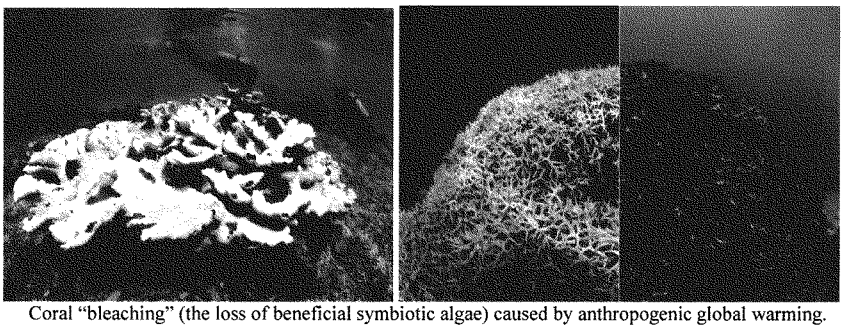


An irony is that these tropical organisms are much closer to the high temperatures that kill them than to the low temperatures that kill them. They are like orchids, you can cool them down a little and they will survive, but you cannot heat them up:

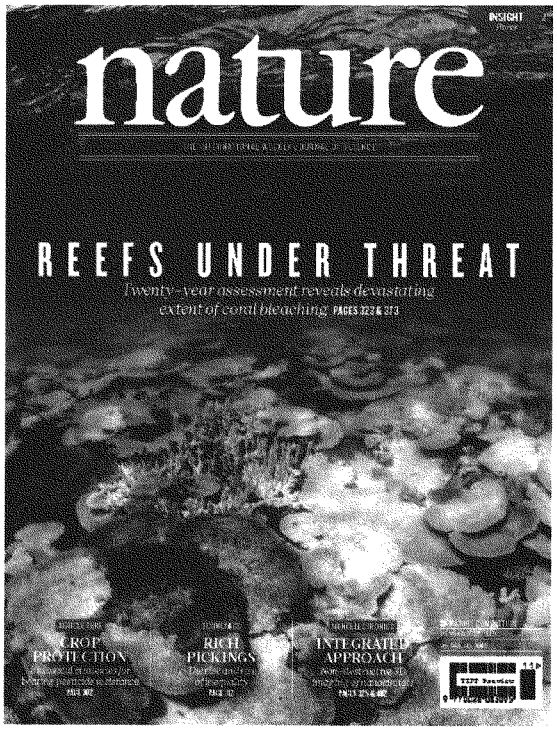
- In tropical waters, corals live within 2°C of the high temperatures that kill them.
- Elevated temperatures cause corals to lose the symbiotic algae which live inside them.
- These symbionts photosynthesize and provide corals with food.
- When corals lose their symbiotic algae, they starve to death.
- These symbiotic algae also give corals their color (the colors of coral are from plant pigments, not animal pigments).
- When the algae die, you can see through the clear animal tissue to its white lime-stone skeleton underneath, hence the term "coral bleaching."

The irrefutable science behind these observations demonstrates that:

- Global warming will cause tropical seas to rise above this 2°C threshold by 2040 – 2050.
- Even before then, short-term temperature spiking episodes (which also cause coral bleaching) are expected (and have already been observed).
- Back-to-back years of high temperatures cause back-to-back bleaching events, as occurred recently on the Great Barrier Reef in Australia (GBR).
- These events are especially devastating because, even if a weakened coral survives the first bleaching episode, there is no time to recover its strength to survive the second.



Coral "bleaching" (the loss of beneficial symbiotic algae) caused by anthropogenic global warming.



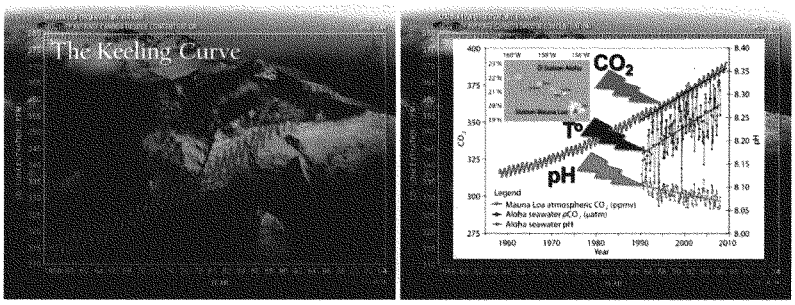
This apocalypse is neither a distant peril nor a hypothetical threat to coral reefs. It is here; it is here now:

- 66% of all GBR corals died within the last two years.
- World-wide, 50% of all corals have died in the last three decades, mostly from climate change and global warming.
- Coral reefs world-wide are not recovering.
- As a result of climate change, most coral reefs are predicted to be gone by 2040-2050, and with them the vast majority of species that constitute their extraordinary bio-diversity.
- Current rates of planetary warming are considered to be too rapid for coral adaptation.
- Even with the benefit of "assisted evolution," whereby we attempt to create coral populations with elevated temperature-tolerances, the scale of the problem and the extremely high temperatures expected under any business-as-usual CO_2 emissions scenario, are considered to be too great for coral survival.

Elevated CO_2 levels affect the ocean in at least two physico-chemical ways:

- Rising temperatures (global warming)
- Falling *pH* (ocean acidification)

These two ocean modifiers have been referred to as the "Evil Twins" of climate change. Whereas global warming causes coral bleaching by killing the symbiotic algae, the solution of CO_2 into oceanic waters causes the *pH* to fall as the ocean becomes more acidic. This future threat is of dire concern because, depending on the CO_2 level, these acidic waters will either slow or prevent entirely the deposition of coral limestone skeletons. This phenomenon is analogous to the commonly understood etching effect of acid rain on limestone tombstones.



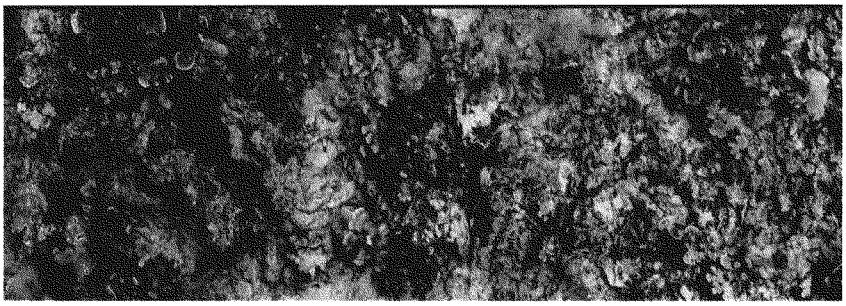
Both atmospheric and marine CO_2 levels have been monitored in Hawaii. All measurements demonstrate, that as anthropogenic CO_2 levels rise, air and water temperatures also rise, and oceanic pH falls.

Both global warming and ocean acidification are expected to destroy coral reefs as we know them by the end of this century. Caitlin SeaView@

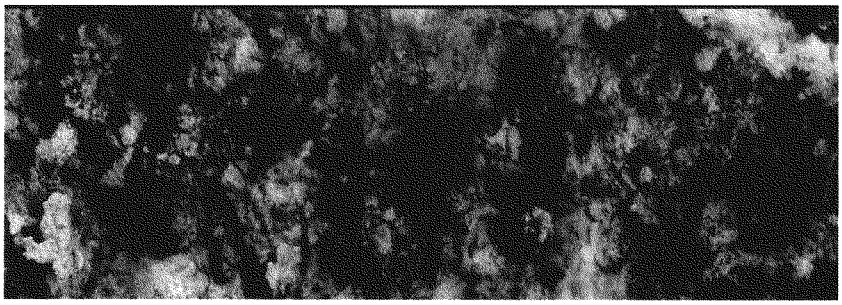
I illustrate the extent of this global problem with two examples, one from the Florida Keys, the other from Discovery Bay, Jamaica.

Florida has lost half of all its living coral since the early1980s. These losses are continuing.

One example from Eastern Dry Rock Reef off of Key West can be seen below. These kinds of losses on shallow water reefs are common throughout the Florida Keys.



Before **1994** Dry Rocks Reef Key West, FL – J.W. Porter

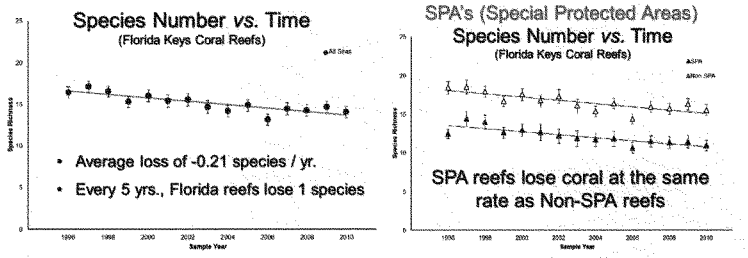


After **2004** Dry Rocks Reef Key West, FL – J.W. Porter

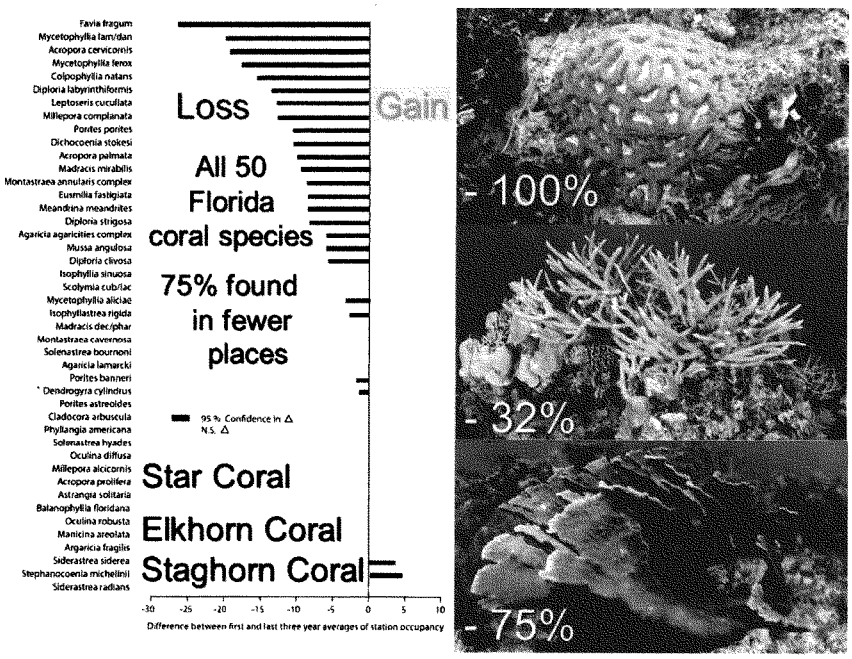
I addition to coral cover, reefs of the Florida Keys are also loosing species rapidly.

- With 43 reefs investigated, on average, Florida reefs lose 0.21 coral species per year.
- That translates to one species lost every 5 years.
- Alarmingly, this rate of species loss is the same both inside the NOAA Marine Sanctuary Special Protected Areas and outside these carefully protected and carefully monitored no-take zones (see graphs below).
- 75% of all coral species in the Florida Keys are now found in fewer places than they were at the beginning of the *E.P.A. Coral Reef Evaluation and Monitoring Program*, which started in 1994.
- One coral species, *Isophyllastrea rigida* has now gone extinct in the Florida Keys.

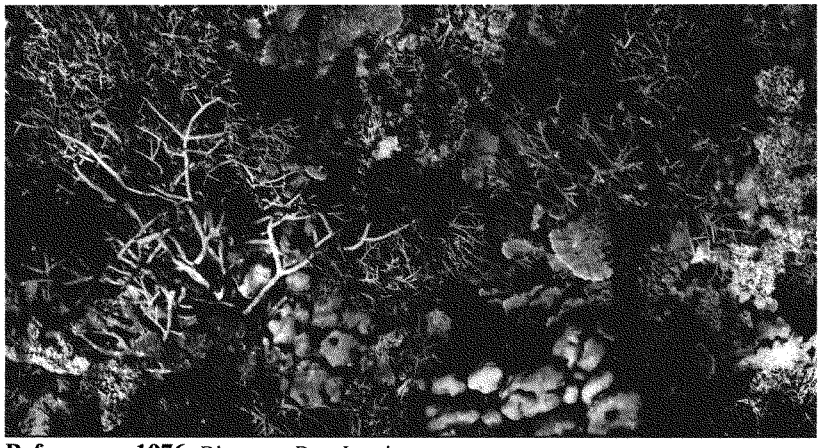
- Once among the commonest corals in the Caribbean, the iconic branching Elk Horn and Stag Horn corals have declined so much that they have been added to the Endangered Species List.



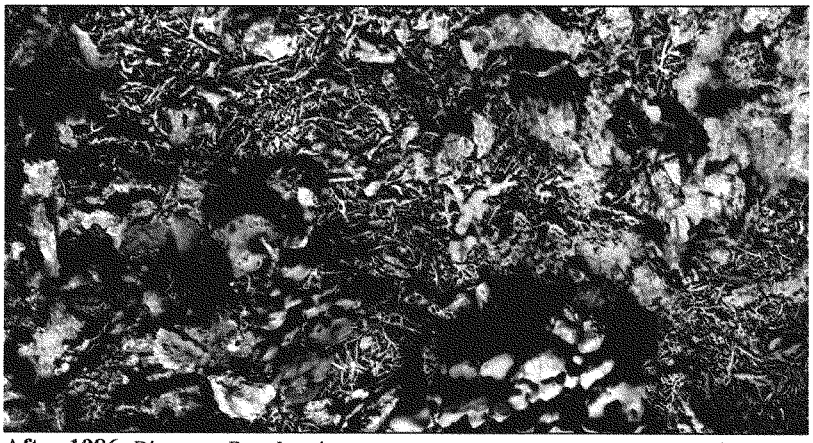
Florida reefs lose on average 1 species every 5 years, both inside and outside the NOAA National Marine Sanctuary Special Protected Areas – J.W. Porter and M. Meyers



Similar losses occur throughout the Caribbean, as illustrated here with this pair of "before & after" photographs taken on shallow-water reefs in Discovery Bay, Jamaica. A combination of bleaching and hurricanes has degraded and converted vast regions along the north coast of Jamaica from coral reefs with high coral cover and high species diversity to rubble zones with low coral cover and low diversity.



Before **1976** Discovery Bay, Jamaica

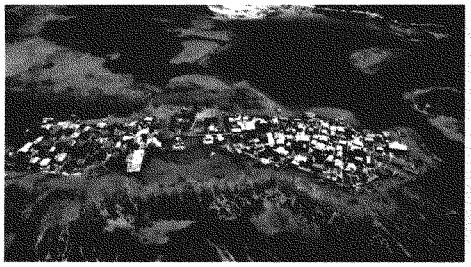


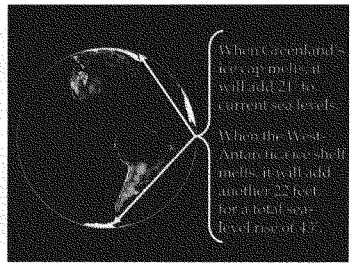
After 1986 Discovery Bay, Jamaica

Finally, elevated CO_2 levels in the Earth's atmosphere will affect the ocean in at least one additional way. It will increase its physical size, causing:

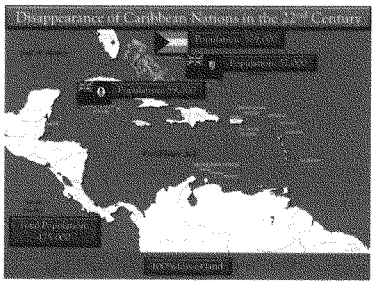
- Sea Level rise, due to:
    - Glacial melt and
    - Thermal expansion

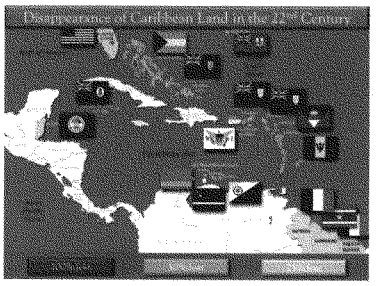
In tropical regions, sea-level rise will have devastating effects on coastal fishing and tourist communities that have grown up near coral reefs. Currently the "average-case" IPCC model predicts that sea levels will rise approximately 2 m by the end of this century. "Worst-case" models, however (which fit the data much better than the average-case models), put this S.L.R. value closer to 3 m. Regardless of which model is right, projecting sea level rise only to 2100 underplays the fact that by 2100, sea level will be rising nearly exponentially. Increases after 2100 will be much faster than before 2100.





Given that sovereign nations like The Bahamas, Turks & Caicos, and the Cayman Islands are comprised exclusively of low-islands (and are therefore without mountainous interiors like Jamaica or Cuba), their existence is threatened by sea-level rise. These three island nations have a combined population of 475,000, all of whom are likely to become climate refugees sometime during the 22nd Century. Pacific island states like Kiribati are already beginning to transfer their population to nearby New Zealand. Other countries in the Caribbean, as well as coastal regions in Florida and elsewhere around the U.S. likewise face a diminution of their coast lines and a significant loss of their land areas (see maps below).





The IPBES report is an alarm bell. It tells us that to save the biological heritage of the Earth and the Ecosystem Services they provide, humankind must change its extractive and exploitative relationship to the natural world. We must stop maligning it and start preserving it.

For coral reefs, programs that reduce coastal-zone pollution are needed in addition to programs that reduce greenhouse gas emissions. We are in a race against time. We are losing.

I was asked to say something about what this House Committee could and should do in response to the IPBES report. All of the agencies you oversee, such as NSF, EPA, NOAA, NASA, *etc.*, should be tasked (and funded!) to undertake broad-scale programs to address the planet's impending biodiversity crisis.

In addition, I would like to suggest that perhaps the most important thing you could do would not cost anything. I recommend that each Member of the *Committee on Science, Space, and Technology* speak to at least one additional Member of Congress about what you have learned today. Tell them that the irrefutable evidence, from both land and sea, is that humankind is destroying species and ecosystems at an unsustainable rate. In addition to wreaking havoc on the natural world, these actions threaten our way of life, our civilization, and, potentially, even our own existence. The full weight of the U.S. government is necessary to address this planetary threat.

Biography

James W. Porter, Ph.D.
Josiah Meigs Professor of Ecology, *Emeritus*
Odum School of Ecology
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James W. Porter is the Josiah Meigs Distinguished Professor of Ecology, *Emeritus* at the University of Georgia. Dr. Porter received both his Bachelor's and Ph.D. degrees from Yale.

He has testified before Congress two times about the effects of climate change on coral reefs. His current research on coral health is funded by the *NIH Ecology of Infectious Disease Program.*

In 2005 he received the *Eugene P. Odum Award* for environmental education from the *Ecological Society of America*, and in 2006, he was elected President of *Sigma Xi*, the Scientific Honor Society with more than 160,000 members worldwide, including all living *Nobel Laureates*. In 2019 he received the *Coral Reef Society*'s top *Eminence in Research Award.*

Dr. Porter's award winning photographs have appeared in *Life Magazine* and the *New York Times*. His work has been featured on the *ABC World News*, *NBC Nightly News,* and *CNN.*

His documentary film, *Chasing Coral*, to which he contributed as the Chief Scientific Advisor and a Principal Cast Member, won the *Audience Choice Award* at the *2017 Sundance Film Festival*, and then went on to win a *2017 Peabody Award* and the *2017 Emmy* for *Best Nature Documentary.*

Chairwoman JOHNSON. Thank you very much. Mr. Goodwin?

TESTIMONY OF JEFF GOODWIN, CONSERVATION STEWARDSHIP LEAD AND AGRICULTURAL CONSULTANT, NOBLE RESEARCH INSTITUTE

Mr. GOODWIN. Chairwoman Johnson, Ranking Member Lewis, Members of the Committee, thank you for this opportunity to provide testimony on behalf of the Nobel Research Institute. The recently published Global Assessment of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services discusses in depth the estimated projections and global biodiversity loss and the perceived negative impacts imposed by the agricultural industry. To the contrary, for more than a decade a movement has been taking place in the ag industry that is returning biodiversity to the land. A significant number of farmers and ranchers, producers, across the country, and around the world, are part of an agricultural revolution, a regenerative revolution, focused specifically on biological diversity, and building biologically active soils.

This movement, however, was not born out of legislation, or regulatory requirement. It was born out of the recognition by innovative producers, who understood the adoption of ecologically and economically sustainable principles would enable them to remain on the land, producing the food and fiber needed for an ever-expanding population. Sixty years ago the agriculture industry operated on cheap fuel and fertilizer. Our industry, and our research, during that time focused on the chemical and physical characteristics of soil, with little to no consideration of the biological interactions. In recent years, prices for food and fertilizer have increased to the point that—become unsustainable for many operations. Many producers have had to make a choice, continue what they've always done, or work with nature to find a new solution.

Born out of equal parts necessity and frustration, producers began to experiment with farming techniques that limited the use of inorganic fertilizer. They began to see that limiting or eliminating tillage reduced their fuel bill, and using the ageless practice of cover crops to keep their fields covered provided numerous benefits to the soil, like preventing erosion, like increasing the soil's water holding capacity, and, yes, increasing biodiversity. In essence, they built a foundation of principles that producers follow today to manage healthy soils.

These soil health principles were set forth to achieve specific goals inherent to all soils. They mimic highly diverse, heterogeneous native rangelands by harnessing the power of biologic interactions between plants and soil microbes. These principles build soil aggregation, which further build soil structure, which increases water infiltration, and ultimately increases the soil's resilience. These principles provide innovative producers a path forward, and substantiate that the conventional farming practices of the last 60 years are not the only way. These principles were developed by producers, for producers. Principles like armoring the soil, keeping the soil covered. Soil cannot be built if it's moving. Optimizing or minimizing disturbances, increasing species diversity,

keeping living roots in the ground as long as possible, and increase, and properly integrating livestock.

In 1949 Aldo Leopold, considered by many to be the father of conservation theory and wildlife management, taught that land stewardship was not only rooted in conservation, but also involved an ethic of stewardship. He wrote that the individual is a member of a community of interdependent parts. The land ethic simply enlarges the boundaries of the community to include soil, water, plants, animals, or, collectively, the land. Simply put, once we understand that humans are not separate from, but are part of, and depend on, the natural community, we develop an ethic to care for the community as a whole.

For years those who oversee the use and protection of our soil, the producers, have been disparaged, and in many cases demonized, for the practices in which they engage. However, the reality is that those entrusted with the mantle of land steward embrace the same ethic taught by Mr. Leopold. Producers today are implementing principles that return biodiversity to the land. This stewardship cannot happen without those stewards on the land. Thank you.

[The prepared statement of Mr. Goodwin follows:]

Written Testimony
Submitted to
U.S. House Committee on Science, Space, and Technology
June 4, 2019 Hearing

Nature in Crisis: Biodiversity Loss and its Causes

Jeff Goodwin
Conservation Stewardship Lead
Noble Research Institute, LLC

Chairwoman Johnson, Ranking Member Lucas, Members of the Committee, thank you for this opportunity to submit a written statement on behalf of the Noble Research Institute, LLC.

Lloyd Noble, an oilman and philanthropist, founded the Noble Research Institute in 1945 to help revitalize agriculture following the Dust Bowl. Mr. Noble was a visionary in land stewardship and conservation, recognizing that "... the land must continue to provide for our food, clothing and shelter long after the oil is gone," and that "no civilization has outlived the usefulness of its soil. When the soil is destroyed, the nation is gone." Today, the Noble Research Institute is the largest independent agricultural research organization in the United States. Among our other efforts in agriculture consultation and education, we conduct agricultural research to connect the five soil health management principles referenced herein to definable outcomes across the U.S. in an effort to enhance a sustainable beef cattle industry.

The recently published "Global Assessment of the Intergovernmental Panel for Biodiversity and Ecosystem Services" discusses in depth the estimated projections of global biodiversity loss and the perceived negative impacts imposed by the agriculture industry. To the contrary, for more than a decade, a movement has been taking place in the agricultural industry that is *returning* biodiversity to the land. A significant number of farmers and ranchers ("producers") across the country and around the world are part of an agricultural revolution, a regenerative revolution, focused specifically on biological diversity and a healthy, biologically active soil. This movement, however, was not born in a laboratory nor was it born out of legislation or regulatory requirements. It was born out of the recognition by innovative producers who understood the need to adopt ecologically and economically sustainable principles to enable them to remain on the land, producing food, feed, fiber needed for an ever-expanding population.

Sixty years ago, the agricultural industry operated on cheap feed, cheap fertilizer and cheap fuel. Our industry and our research during that time focused on the chemical and physical characteristics of soils with little to no consideration of biological interactions within the soil. In recent years, prices for feed, fertilizer and fuel have increased to a point that has become unsustainable for many operations. Many producers have had to make a choice: continue doing what they have always done, or work *with nature* to find a new way to farm and ranch. Born out of equal parts necessity and frustration, producers began to experiment with farming techniques that limited the use of inorganic fertilizer, fuel and feed. They began to see that limiting or eliminating tillage reduced their fuel bill, and using the ageless practice of "cover crops" to keep their fields covered provided numerous benefits to the soil (i.e., preventing erosion, increasing water holding capacity and increasing biodiversity). In essence, they built a foundation of principles that many producers follow today to manage healthy soils.

These soil health management principles were set forth to achieve specific goals that are inherent to all soils. They are based on mimicking highly diverse, heterogeneous, native rangeland plant communities by harnessing the power of biologic interactions between plants, soil microbes, fungi and other of life in our soils. These principles build soil aggregation, which further builds structure. These principles have proven the path forward for many innovative producers and substantiated that the conventional farming practices of the last six decades are not the only way. The following soil health management principles were developed by producers for producers:

1) **Armor the soil:** Soil health cannot be built if the soil is moving. Building organic matter on the soil surface armors and protects the soil from erosive processes. Keeping the ground covered also serves as a mitigation mechanism for soil temperature. Excessive increases in soil temperature can have drastic and destructive effects on soil microbial life. Once soil temperatures reach 140° F soil bacteria die. The soil must be covered to minimize bare ground, this is largely accomplished by forage and crop residue.

2) **Optimize disturbance:** Physical soil disturbance, such as tillage, alters the structure of the soil and limits biological activity. If the goal is to build healthy, functional soil systems, tillage should only be use in specific, limited circumstances. While tillage is a detrimental disturbance, not all disturbances harm the soil. In fact, some are quiet beneficial and should be optimized. Grazing, prescribed fire, herbicide applications, among others, are all disturbances that can, if properly managed, be beneficial. For this reason, we use the term optimize disturbance to ensure that the timing, frequency, intensity and duration of these management activities are implemented in a planned manner.

3) **Increase diversity:** Increasing plant diversity above ground allows for a more diverse communities below ground. Specific soil microbes require specific plant types. The more diverse the microbial population in the soil, the better the plant species will perform due to increased biological activity.

4) **Keep living roots in the ground all year:** Soil microbes tend to utilize active carbon first. Active carbon is the exudates from living plant roots. Therefore to keep soil biology working as long as possible, a living root in the ground is ideal. A living root provides a food source for beneficial microbes and provides opportunity for symbiotic relationships between plant roots and mycorrhizal fungi.

5) **Properly integrate livestock:** Grasslands evolved under grazing pressure. Soil and plant health is improved by grazing, which recycles nutrients through improved manure distribution, reduces plant selectivity and increases plant diversity. The most important factor in grazing systems is the management of stocking rate and allowing, in some manner, adequate rest periods for the plant to recover before being grazed again.

Principles over Practices

The great challenges facing the U.S. agricultural industry as a whole are numerous and daunting. However, to solve those challenges, one must determine the root of the problem. For much of the past six decades, the agriculture industry admittedly focused on treating symptoms with practices and inputs rather that addressing the problem with science-based, systems-focused principles. Dating back as far as the early 1900s, producers tended to focus more on plowing the prairie with industrial technology and machinery rather than understanding the soil's ecology. To most, soils were largely viewed as a medium to grow crops.

Innovative producers today understand that we do not solve ecological problems by implementing practices, rather we implement principles. We can and are addressing ecological degradation by following principles that rebuild ecological processes and habitat from the ground up rather than focusing on specific singular species or management practices. It all begins with maintaining a solid foundation with healthy soil as the cornerstone to any agricultural enterprise.

Soil health is often defined as "the continued capacity of the soil to function as a vital, living ecosystem that sustains plants, animals and humans." While many people today think of "soil health management" as a new strategy, it's actually not. In 1949, Aldo Leopold stated in *A Sand County Almanac*, "Land, then, is not merely soil; it is a fountain of energy flowing through a circuit of soils, plants and animals".

Mr. Leopold is widely considered to be the father of modern conservation theory and wildlife management. He taught that land stewardship was not only rooted in conservation but also involved an ethic of stewardship. He wrote that all ethics rest upon the single premise "... that the individual is a member of a community of interdependent parts. The land ethic simply enlarges the boundaries of the community to include soils, waters, plants, animals, or collectively: the land." Stated another way, once we understand that humans are not separate from, but are part of and depend on the natural community, we will develop an ethic to care for the community as a whole.

Fast forward to today: a lot has changed in how many "view" the soil and those entrusted with the stewardship thereof. For years, our soil, and specifically the health of our soil, has been taken for granted. And those who oversee the use and protection of our soil—the producers, the stewards of our land—have been disparaged and in many cases demonized for the practices in which they engage. However, the reality is that those entrusted with the mantle of responsibility as land stewards embrace the same ethic taught by Mr. Leopold. This is land stewardship, and land stewardship does not happen without land stewards.

Defining the Steward

Most of the time you can't see them from the road, but if you take the time to look across rural America, you'll find producers working tirelessly in an effort to ecologically steward their lands, raise their families, and earn a living wage. Many of these stewards are using the same tools that others claim are degrading the environment to effectively regenerate it.

In a 1933 article published by Mr. Leopold in *Game Management*, he states, "...game (wildlife) can be restored by the creative use of the same tools which have heretofore destroyed it- axe, cow, plow, fire and gun." He goes on to state "...management is their purposeful and continuing alignment," emphasizing how these tools can be implemented or managed to drive their potential ecological outcome.

The management of the "axe" represents the management and sculpting of habitat, specifically woody species encroachment. The "cow" represents grazing management, including stocking rate along with the timing, frequency, intensity and duration of the grazing event. The "plow" represents soil management, optimizing habitat disturbance, managing for specific plant communities, even planting them. "Fire" represents the planned application of prescribed fire. Fire molded many of our rangeland systems and many have degraded due to its absence. Finally, the "gun" represents managing wildlife populations with science-based data in an effort to conserve and eliminate declining wildlife populations and declining biodiversity.

Applying the Principles Today

No-till and Cover Crops - Producers today are actively and independently beginning to re-implement these principles into their operating plans, all the while looking for new (and old) tools to help achieve environmental and production goals. With the primary soil health management principle being "armor the soil", keeping the soil covered is paramount. Conventional tillage practices are extremely damaging to soil biological processes and increase the susceptibility of the soil to erode. Many innovative producers have embraced no-till agriculture and many are out-producing their conventional county cohorts. The use of cover crops has increase exponentially over the past several years. Cover crops are one commonly utilized tool in agronomic systems to meet several management goals, such as keeping the ground covered, adding biological diversity and increasing pollinator habitat. Cover crops are an incredible tool that can be utilized to directly or indirectly meet any and/or all of the five soil health management principles in cropland and pasture systems. Many producers have been utilizing mixed species cover crops in cropland and pasture systems to increase diversity, increase organic matter, increase soil microbiological function and more. Simply planting cover crops is not one of the principles. Cover crops are but one of the facilitators that enhance the farmer's ability to follow the five soil health management principles.

Fire - The Great Plains, once stood as one of the most biologically diverse prairie ecosystems in the country. The two primary tools that molded this system over eons were herbivory (grazing) and fire. There are multiple reasons these rangelands are not in the condition they once were, including overgrazing (due to poor management and not the mere presence of the animals themselves), land fragmentation and woody encroachment. However, the most impactful is the suppression of fire. Limiting or completely removing fire from the landscape reduced nutrient and energy cycling and more importantly allows woody species to encroach and recruit, eventually creating a woodland. Fire in this ecological region is a core ecological process often overlooked, more often, completely removed. Historically, every square inch of land in the Great Plains evolved under a fire dependent ecology, meaning the proper function of that ecosystem and its habitat for wildlife species depended on fire and an integral component. Today, producers are increasing the use of prescribed fire to tailor its application and meet specific ecological outcomes and management objectives.

As with the use of cover crops to keep the ground covered thereby building healthy soil, timely and well-planned application of prescribed fire can actually limit the duration the soil is bare following fire. Given adequate soil moisture, cover can return quickly during the growing season. Prescribed fire can additionally aid in soil nutrient cycling and availability, often providing legacy effects for additional years.

Prescribed fire also aids in managing diverse plant communities, thus supporting habitat requirements of many game and non-game grassland bird species. Producers applying prescribed fire are actively enhancing the plant community structure for improved habitat, improving forage quality and quantity, and effectively addressing brush management. Studies have indicated that forage quality is increased and year end forage quantity is not reduced following prescribed fire. A primary driver of this result is controlling woody encroachment in prairie ecosystems. Consequently, brush management is the most common purpose for applying prescribed fire.

Air quality is often the scapegoat for most dissenters of prescribed fire. The primary air concern regarding prescribed fire is smoke management. Numerous environmental factors can have positive and negative effects on smoke dispersion during a prescribed fire, including mixing

height, transport wind speed and wind direction. Today's producers are using precise weather forecasting, proper planning and appropriate application of prescribed fire to mitigate air quality issues. Moreover, an oft-overlooked benefit of prescribed fire is that for some plant species, smoke actually increases seed germination.

Grazing - Grazing management is another tool that has defined agricultural production in the Great Plains region and beyond. Plant communities that make up the majority of ecologically diverse prairie systems evolved over time under some type of grazing influence. Largely the timing, duration, frequency and intensity of the grazing event over time has a tremendous impact on the composition and production of these rangeland plant communities. The art of applying proper grazing management is found in, among other things, the ability to be flexible with forage utilization and return intervals.

Beneficial grazing systems have been developed, tested, well published in the scientific literature and implemented across the country for decades. Producers are implementing grazing systems with an intentionality toward a given environmental climate, balancing the timing, duration, frequency and intensity of the grazing event.

Grazing systems are a valuable part of the overall grazing plan; however, no grazing system will be effective if stocking rate is not addressed. Stocking rate is the single most important grazing management decision a producer can make. Stocking rate influences forage utilization, grazing distribution, and over time can influence either positively or negatively the productive capability and diversity of rangeland plant communities and wildlife habitat. Grazing management is a complex part of managing a ranch, but today's producers are focusing not only on stewarding an ecological system and an animal production cycle that is constantly changing, but also on doing so in a manner that allows them to sustainably deliver their products cost-effectively into fluctuating markets.

Conclusion

Market forces on the inputs and outputs of farmers and ranchers across the United State have combined with the land stewardship ethic of those same individuals to create a movement in the agricultural industry focused on the application of fundamental principles of land stewardship, principles that can be applied across all aspects of the agricultural sector. Despite the growing theme in our public discourse laying the blame for global biodiversity loss at the feet of the agriculture sector, over the past decade, the movement is demonstrating that, in fact, many agricultural producers, as well as the sector as a whole, are actually helping return biodiversity to the land.

As the movement continues to grow, unimpeded by the burden of restrictive legislation and regulations, so too will the biodiversity beneficial to the production food, feed and fiber and ecosystem services necessary to support an ever-expanding population.

Douglas Jeffrey (Jeff) Goodwin

Short Narrative Biography

Jeff Goodwin serves as the Conservation Stewardship Lead at Noble Research Institute. Mr. Goodwin provides leadership in the development and implementation of the institute's land stewardship programs and activities. Mr. Goodwin received a BS and MS degree in rangeland management from Tarleton State University and is currently pursuing a PhD at Texas A&M University-Kingsville. Before coming to the Noble, Mr. Goodwin was the state rangeland management specialist for USDA's Natural Resources Conservation Service (NRCS) in Temple, Texas. Mr. Goodwin has over 20 years' of experience working directly with producers and land managers implementing stewardship focused management. Jeff and his family are also commercial cow/calf producers in central and north Texas.

Chairwoman JOHNSON. Dr. Monfort.

TESTIMONY OF DR. STEVEN MONFORT, DIRECTOR OF THE SMITHSONIAN NATIONAL ZOO AND CONSERVATION BIOLOGY INSTITUTE

Dr. MONFORT. Thank you, Chairwoman Johnson, Ranking Member Lucas, and distinguished Members of the Committee. My name is Steve Monfort, and I'm the Director of the Smithsonian's National Zoo and Conservation Biology Institute. In addition to representing my zoo colleagues, I'm honored today to represent my Smithsonian partners from—Environmental Research Center, our Tropical Research Institute, and the National Museum of Natural History, and others united under Smithsonian's umbrella, called the Conservation Commons, which is an institution-wide effort designed to foster collaboration in tackling complex conservation problems.

At the National Zoo you probably know that we care for and conserve some of the rarest species on Earth, but what may be less known to you is that the Smithsonian has been studying biodiversity for 170 years plus. Today, hundreds of Smithsonian scientists and scholars work across the spectrum of biodiversity and conservation science, from genomes to individuals and populations, to forests, watersheds, and fisheries, to understanding the impacts of infrastructure development, pandemic diseases, and human/animal conflict, work that is focused on understanding and sustaining a biodiverse planet, which we've been hearing is the very fabric of what we define as nature, and all of its vital contributions to people, and all life on Earth.

As evidenced by our incredible new fossil hall, which I'm sure you'll all have a chance to see soon, our collections represent the best planetary record that humanity possess. They document long-term baselines, trends, and changes about the planet, biodiversity, and even human cultures. And what we've learned is this, it took 200,000 years for the human population to reach one billion people, but only 200 to reach nearly eight billion, and this has resulted in profound planetary change.

The IPBES report essentially confirms what we have long known—humans have made things very tough for nature. And yet, as you've also heard, we're inextricably linked to, and connected, and dependent upon biodiversity, upon nature. Because, quite literally, and very simply, every breath that you take, every drop of water that you drink, every bite of food that you consume, is in one way dependent upon biodiversity and functioning ecosystems.

Over the next decade we know that trillions of dollars are going to be invested in things like infrastructure development, and land conversion, to really—to support the livelihoods of a growing human population. But without better planning, proper planning, this development will continue to be a major driver of animal mortalities, of habitat fragmentation, species invasions, and the spread of pathogens that are responsible for global pandemic disease threats.

The ongoing and real threats to biodiversity are clearly daunting, and yet, if we just bombard the public with messages of gloom and doom, absent any focus on solutions, we risk fostering a sense of—

that nothing anyone does is going to make a difference. So, to counter this, in 2017 the Smithsonian launched Earth Optimism, which is a worldwide forum for sharing and curating stories of conservation success. Our next summit aims to reach a billion people around the world on the 50th anniversary of Earth Day, which will be in April 2020, and, of course, you're all invited to join us.

In my own experience, increasing collaboration increases the chance of finding solutions, and I'd like to share two examples that I believe demonstrate that. The Scimitar Horned Oryx is a large, magnificent, desert-adapted antelope that once roamed widely across the entire Sahelian grasslands of North Africa, from Senegal to North Africa, like American bison, widely distributed. The species was declared extinct in the wild in the 1980s as a result of war and overhunting. And, fortunately, though, large populations of the species were maintained in human care, both in zoos and private collections worldwide, including at the Smithsonian.

In 2010, the Smithsonian helped to convene a global network of stakeholders that included the governments of Abu Dhabi, which managed large populations of oryx in their own herds, and the government of Chad, which sought to restore the species to their historic rangelands. And so it was through this diverse partnership that, in 2016, I had the amazing opportunity to personally witness the first group of oryx to touch Chadian soil in more than 30 years. Reintroducing oryx back to Chad is really just the first step in restoring ecological balance in an entire Sahelian Grasslands ecosystem, upon which people depend for their livelihoods.

Another great example comes from our Tropical Research Institute in Panama. As you know, the Panama Canal is a massive lifeline of global commerce, but large ships were routinely colliding with humpback whales, which was, of course, catastrophic for the animals, but also had the potential for disrupting global trade. Our scientists used GPS tracking devices to monitor the movements of these whales, and, through collaboration with the Panama Canal Authority, these data were used to re-establish new shipping lanes, which resulted in a 93 percent reduction in ship/whale collisions.

So win/win solutions for people and nature will require us to adopt new standards of practice that recognize that integrating conservation and science across multiple sectors into development practice is good for our economies, it's good for our families, and good for every global citizen, because we all have a stake, and will benefit from sustaining a biodiverse planet. Nature must have a place at the decisionmaking table, not as an interloper, but as an existential partner, if it is to fulfill its role in providing its incredible benefits to current and future human societies. Thank you.

[The prepared statement of Dr. Monfort follows:]

Smithsonian Institution
Written Testimony of
Steven L. Monfort, Director, Smithsonian's National Zoo and Conservation Biology Institute
Nature in Crisis: Biodiversity Loss and Its Causes
House Committee on Science, Space, and Technology
U.S. House of Representatives
June 4, 2019

Introduction

Thank you, Chairwoman Johnson, Ranking Member Lucas, and distinguished members of the Committee, for the opportunity to provide testimony to you today on Biodiversity loss and its causes. My name is Steven L. Monfort and I am the Director of the Smithsonian's National Zoo and Conservation Biology Institute.

At the National Zoo we care for some of the rarest species on earth, and along with that comes a moral and ethical responsibility, shared by all internationally-accredited zoos, to work across the continuum from individual animals in our care to the work we are doing to save species in nature. Although trained as a wildlife veterinarian and research scientist, I now lead a team of dedicated scientists and animal care professionals within the broad discipline of conservation biology: a value-driven discipline that is based on the premise that biological diversity and functioning ecosystems are of benefit to current and future human societies, and all life on earth.

I also co-founded the Smithsonian's Conservation Commons, a Smithsonian-wide effort to bring the cumulative expertise of our scientists together—along with key partners across sectors—to tackle complex conservation problems on a global scale. It is an honor to represent the work of my colleagues, not just from the National Zoo and Conservation Biology Institute, but also from our Environmental Research Center, our Tropical Research Institute, the National Museum of Natural History, and numerous researchers all over the world.

The Smithsonian has been studying biodiversity for more than 170 years. We provide the basic science that tells us how the planet has changed. We look back over millions of years to understand where we have been, and forward to understand where we are going. It is important to note that our scientists have also teamed up with the Smithsonian Science Education Center, the Center for Folk Life and Cultural Heritage, Smithsonian Enterprises, and Smithsonian Facilities, to redouble efforts in conveying science-based solutions to the public: through community curricula, through building design for energy efficiency, and through best practices regarding sustainability.

Why Does Biodiversity Matter?

The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) is the global body that assesses the state of biodiversity and nature's contributions to people. The recent findings IPBES report highlight the need for this hearing. To us, the findings of the report are startling, but not surprising. The factors identified as drivers of loss in biodiversity have been well known for years, it is the scale of the findings that are cause for concern. Dire findings can seem overwhelming, and it can feel like there is nothing we can do to reverse the trend. However, that is not true. There is reason for optimism.

It is not too late to address biodiversity loss, but doing so will require leadership, collaboration, and speedy cooperation, including in areas of conservation, technology, and science. It is not hyperbole to say, our health and wellbeing depends on it.

As is stated in the recent Global Assessment Report from the Inter-Governmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES report), when we talk about "biodiversity," we are referring to nature and its vital contributions to people, and which is "essential for human existence and good quality of life." Biodiversity provides the structural integrity to what we broadly define as nature. Humans are inextricably linked and dependent on this diversity because every breath we take, every drop of water we drink, and every bite of food we consume is in one way or another dependent on biodiversity and functioning ecosystems. But nature's benefits also include things like carbon sequestration, erosion and flood control, biochemicals, pharmaceuticals, genetic resources, industrial products, productive fisheries, pollinator services, and so much more, adding up to trillions of dollars to the global economy each year.

The World Economic Forum's Global Risk Report 2018 lists ecological collapse and biodiversity loss among the top 10 risks in terms of impact to humankind. And while an awareness of the dangers presented by climate change has increased, biodiversity losses related to habitat destruction and fragmentation, overharvesting, invasive species, pollution, and generally, the adverse human impacts on ecosystem function are often underappreciated.

Biodiversity loss is not a new phenomenon, we have been documenting it for decades. It took 200,000 years for the human population to reach 1 billion people, and only 200 more to reach nearly 8 billion. Today, human impacts on natural resources and biodiversity have resulted in planetary changes so profound that we have entered a new geological era, the Anthropocene. As a simple illustration of how spectacularly dominant the human footprint has become one need only look at our livestock, which now constitutes 96% of all mammalian biomass on the planet, whereas wild mammals represent only 4%. Likewise, for birds, chickens constitute 60% of the biomass of all avian species on Earth.

And while it is certainly true that climate change is a real threat to biodiversity, it is the escalation of infrastructure and development in parallel with human population increases that been and will continue to be the major drivers of biodiversity loss. Over the next decade trillions of dollars will be invested in new infrastructure—roads, hydroelectric dams, mining, agriculture, tourism, and energy development—that supports livelihoods for billions of people. Without proper planning, this development has potential for creating devastating losses in cultural and biological diversity. As just one example, it is estimated that 15 million miles of new roads will be built by 2050—enough to circle the globe 625 times—and 90% of these new roads will be in developing countries where much of world's biodiversity exists. This development will result in direct impacts on biodiversity such as animal mortalities, collisions, barriers to movement, and indirect impacts such as habitat fragmentation, increases in hunting, species invasions, pollution, the spread of pathogens with pandemic potential, and deforestation and degradation with a reduction in ecosystem services.

Biodiversity annually yields trillions of dollars in economic benefits, with 70% of the world's poor deriving their livelihoods from natural resources. And the loss of biodiversity is directly linked to increases in global pandemic disease threats, crime associated with wildlife trade and trafficking, as well as conflicts related to scarcity of natural resources like water and livestock grazing, amongst others.

Nature's benefits are not limited solely to our physical survival, but also to our spiritual well-being and our cultural identities. In fact, the very origins of environmental conservation lie buried deep within our ancient cultures, traditions and even in our religious beliefs. In short, both our biological and cultural diversity—our very identities—are interwoven within the rich tapestry we define as nature.

Efforts to set aside protected areas and national parks have proven useful, but they are insufficient for sustaining a biodiverse planet. That is because we now live on a planet that has effectively become a landscape mosaic of diverse land uses, and we have yet to fully understand how to effectively manage human development while mitigating the adverse impacts on biodiversity and ecosystem function. As the world seeks to address issues like climate change, we must act with greater urgency, and with new and swift ways to collaborate across disciplines, cultures, and time-zones to stem biodiversity loss. Sustainable infrastructure development has to be the new norm based on research and the development and implementation of a new set of best practices. The Smithsonian and its colleague organizations are up for the challenge.

The Role of the Smithsonian

Throughout its 172-year history the Smithsonian Institution has earned its reputation as one of the world's great knowledge institutions. While our buildings, products, events, and exhibits share knowledge with the public and partner organizations, our researchers and curators contribute to this knowledge every day. But less widely known, is that hundreds of Smithsonian scientists and scholars work across the spectrum of biodiversity and conservation science: from genomes to individuals and populations; to forests, watersheds and fisheries; to understanding the impacts of infrastructure development, pandemic diseases and human-animal conflict; our scientists are focused on understanding and sustaining biodiversity.

For example, our life-science researchers are experts in taxonomy, natural history, physiology and ecology, and our paleontologists provide geo-historical data and analyses essential for placing current changes in a deep-time perspective. We are an authoritative source for scientific information on species extinctions and other critical conservation issues at the level of both species and ecosystems. The Smithsonian has the long-term data and expertise to study human impacts (e.g., deforestation, desertification, climate change, ocean acidification, invasive species, overharvest of natural resources, and pollution) over an unmatched range of temporal and spatial scales, and to model outcomes and develop mitigation strategies. Our expertise ranges from analyzing landscape and seascape changes to monitoring environmental and ecological data around the globe. We deploy state-of-the-art methods, ranging from geospatial technologies to assess and monitor ecosystem changes revealed by satellite imagery to genomic analyses exploring the links between genetic variation and functioning ecosystems. We have built and monitor a global network of forest plots (ForestGEO), we are core partners with the National Ecological Observatory Network (NEON), and we are developing an analogous network for coastal ocean ecosystems (MarineGEO). Our scientific platforms support investigations of tropical and temperate ecosystem dynamics, carbon flux, and the impacts of climate change on biodiversity and ecosystem function.

Our physical collections are unparalleled and support understanding both of ongoing changes and of information relevant for crafting solutions. We hold the largest and most comprehensive collections of biological specimens in the world, including frozen biorepositories of individuals, and even whole communities of organisms. Some specimens date back centuries and hold potential for comparing current and past geographic ranges, phenology, and DNA; our collections will serve similar essential

purposes for future conservation scientists. Also, we manage an extensive and expanding living collection of plants, animals, and fungi that act as insurance populations to safeguard against extinctions and provide stock for future reintroductions. We have developed genetic management tools tailored to small captive populations that focus on effective ways to sustain species that are extremely difficult to study in their natural environments.

Our scientists are leaders and innovators in species conservation, including discovering the link between genetic diversity, health and reproduction in wildlife species; establishing the critical importance of migratory connectivity; pioneering the fields of endangered species assisted breeding, endocrinology and cryobiology. Our programs have reintroduced endangered species such as golden lion tamarins to the Atlantic coastal rainforests of Brazil, black-footed ferrets to the great American plains, Przewalski's horses to the Gobi Desert of Mongolia and China, and scimitar-horned oryx into the Sahelian grasslands of North Africa.

Examples of Smithsonian Biodiversity and Conservation Science

The full scope of the Smithsonian's contributions to Conservation science are many and varied, with significant contributions from each of our science and research units. There are simply too many to name, but highlights include:

Smithsonian Environmental Research Center (SERC).

SERC research addresses the global interactions of humans with the planet's biosphere, concentrating on linked coastal ecosystems, where 70% of the human population resides and where most of U.S. economic enterprise is based. SERC scientists seek to understand and inform solutions for major problems of climate change, pollution, land-use and habitat alteration, over-fishing, and invasive species.

- **Marine Invasive Species.** SERC is home to the largest most comprehensive program in the world on marine invasive species, a source of billions of dollars of impacts annually in the U.S. Designated by Congress in the National Invasive Species Act of 1996, SERC works with the U.S. Coast Guard to track management practices of ballast water in commercial shipping – a major source of planktonic propagules for invasive species. All commercial ships arriving to all ports in the U.S. are required to report to SERC on their ballast water management releases, and to exchange their ballast water in mid-ocean. SERC conducts surveys of U.S. bays and ports for invasive species and maintains a national database for all marine and estuarine invertebrates and algae – over 550 species.

- **Biodiversity of Nearshore Coastal Ecosystems.** SERC's 50 years of biodiversity research tracks long-term changes in composition and abundance of all species of fish and invertebrates in Chesapeake Bay, the nation's largest estuary. SERC developed a genetic bar code library for fish and invertebrates in the Bay and provides counsel to fishery management on protecting and recovering stocks of fish and shellfish.

- **Smithsonian's Marine Global Earth Observatory**. SERC is the national headquarters for the Smithsonian's Marine Global Earth Observatory network, which works with partner institutions and countries to make long-term standardized measures of changes in the biodiversity at 15

nearshore coastal sites in the Americas and other locations around the globe. This is a developing network, which will increase to approximately 50 sites in the next 15 years.

National Museum of Natural History (NMNH)
Science at the Smithsonian's NMNH stands upon a grand legacy of exploration, discovery, premier collections-based research and public outreach. Our science today tackles fundamental scientific challenges, has global impact on society and is widely cited by the greater scientific community. Our collections are fundamental to understanding the world's natural and cultural diversity, and the development of sustainable plans for the future.

- To standardize the preservation of Earth's biodiversity at a global scale, the Global Genome Initiative (GGI) was created to provide a one-stop index to all publicly available scientific genomic samples on Earth, working with an expanding network has 87 partners from 31 countries with over 3 million genetic samples available for research.

- In partnership with BGI Shenzhen, and many others, in what is considered a *moonshot* for biology, we have launched the Earth BioGenome Project, which aims to sequence, catalog and characterize the genomes of all of Earth's eukaryotic biodiversity over the next ten years. Outcomes will be essential for developing new drugs, creating new bio-synthetic fuels, biomaterials and food sources for the rapidly growing human population. Ultimately, results will help find new solutions for preserving biodiversity and sustaining human societies.

- The "Healthy Reefs, Healthy People" Initiative is a project coordinated by the NMNH through a field site in Ft. Pierce, Florida. This multi-institutional, multi-country partnership produces a science and community-based "Report Card." The project provides trusted information to create conservation management actions at the local, national, and regional level across four countries. In some cases, communities are already measuring increasing fish populations as a result.

Smithsonian's National Zoo and Conservation Biology Institute (NZP/SCBI)

We are known for excellence and leadership in zoo and conservation science, and our science-based approach to animal management and public education. We conduct world-class research, for pioneering science-based solutions to stem the loss of biodiversity, for aiding in the survival or recovery of species and their habitats, and for building international capacity in conservation biology. Our scientists were among the founders of the field of conservation biology, and continue as leaders today, with global perspectives, diverse expertise, and long-term experience in conducting inter-disciplinary zoo- and field-related research. NZP/SCBI leads in the study, management, protection, and restoration of threatened species, ecological communities, and ecosystems.

- Scientists partnered with Peru LNG to sustain biodiversity during and after the construction of a 400-km long natural gas pipeline across the Andes mountains. Such partnerships can assist in designing smart, biodiversity-friendly infrastructure projects that ensure economic, social and environmental sustainability while protecting biodiversity and ecosystem services.

- Ensuring excellence in animal care and breeding for some of the rarest species on earth, our scientists and researchers are partnering to reintroduce iconic endangered species such as

golden lion tamarins to the Atlantic coastal rainforests of Brazil, black-footed ferrets to the great American plains, and scimitar-horned oryx into the Sahelian grasslands of North Africa.

In Panama, our **Smithsonian Tropical Research Institute (STRI)** serves as the home of the ForestGEO program, which is a global network of scientists and 67 forest research sites in 27 countries where scientists monitor more than 12 million trees in an effort to advance our understanding of how forests respond to environmental change.

Smithsonian's Global Health Program—Impacts on Human Health

The drivers of biodiversity overlap with the drivers of disease emergence: human population growth, land use change, and increased human-animal interactions. To most effectively preserve both biodiversity and human life, we must pursue a holistic and multidisciplinary approach. The "One Health" paradigm addresses biodiversity and health concerns by evaluating human, animal, and environment data. The Smithsonian has been doing this for decades. We have a broad range of expertise—from landscape ecologists, Geographic Information Systems (GIS) specialists, wildlife health veterinarians, geneticists, animal care staff, reproductive physiologists and molecular diagnosticians—all working to address these issues. The most critical piece to the puzzle is partnerships, including regional, transboundary and international partnerships to make sure our work is broadly effective. Just as critical is the need to prepare the next generation to keep these efforts ongoing.

Our team collaborates in a global disease-surveillance project—PREDICT—working in 30 countries to strengthen capacity for detection and discovery of viruses that can move between animals and people and that have pandemic potential. We know that pandemics are most likely to emerge in areas where humans develop previously undisturbed ecosystems, which brings wildlife, livestock and humans into close proximity. Responding to pandemics like Ebola and SARS can cost in the tens of billions of dollars, whereas new knowledge about viruses can help to predict where pandemics are most likely to occur, improve responsiveness, and ultimately save human lives. There is an urgent need to determine causal relationships between biodiversity loss and health, in order to guide appropriate interventions that mitigate risks posed to animal and human health.

Understanding the threats. To best address the threats to human and wildlife health:

- Our landscape ecologists deploy the latest technology and partner with other entities (e.g., NASA, foreign governments, NGOs) to not only evaluate but forecast land use change, but also to investigate on-the-ground changes in land management including features such as fencing, roads and infrastructure development, which can have a direct impact on the survivability of species.

- Our veterinarians study how increase human-livestock-wildlife interactions lead to increasing rates of disease transmission among species. Already our team has discovered over 1,200 novel mammalian viruses, and modeling shows that there are over 500,000 viruses as yet undiscovered. We are gathering and interpreting the data and now prioritizing risks that best need our attention.

- Our scientists are working to understand human behaviors and cultural norms, which can impact both human and animal survival. Along with the Office of Science and Technology Policy, we are collectively working to bridge the hard and soft sciences to better understand the factors that lead to land use change and increased human-animal interactions.

Mitigating the threats. Given that living with animals is a reality, and that human-animal interactions are on the rise, learning to live safely along with animals is an effective method of preserving biodiversity. Examples include:

- Our scientists seek to understand the causes and solutions related to human-elephant conflict in Southeast Asia, including animal movements, sources of conflict, and the design of methods to mitigate impacts, including providing new knowledge needed to guide public policies, supporting the creation of public service/education announcements and community engagement. These efforts have all helped to save both animal and human lives.

- Our veterinarians have identified that living in close proximity to bats can present major health risks for humans, and they have worked with public officials to raise awareness about this issue, and to educate the public about how to live safely with bats.

- Our wildlife health teams have developed international training programs to help save humans AND wildlife, including deploying new knowledge gained from work on wildlife under human care at the NZP/SCBI to some of their counterpart species in nature (e.g., giant pandas, mountain gorillas, rhinos).

The Smithsonian's Multiplier Effect

While our scientists work worldwide to generate and share knowledge to conserve biodiversity, they also work across disciplines to amplify the work and create impact in communities:

- **Smithsonian Science for Global Goals:** Smithsonian scientists and educators have teamed up with the Inter-Academy Partnership to develop community curricula—available online to all—which are helping the world's future decision makers learn how to analyze the complex issues facing us as a society. The first module, "Zika!" which helps communities develop ways to prevent mosquito-borne illness, is already being applied and is protecting the health of many communities.

- **Increasing Sustainability of Smithsonian Research and Education Facilities:** Even in some of our oldest museum buildings, the Smithsonian has been moving to improve the sustainability of our infrastructure, and has won many LEED certifications in recent years. The SERC constructed the first LEED Platinum science research facility in the U.S., and is now developing plans for a net-zero emissions facility near the Chesapeake Bay to serve as a meeting place for world experts to solve large ecosystem challenges.

- **Training the next generation.** Training well-informed technicians, managers, researchers, and leaders (across sectors) continues to be a major component of the Smithsonian's contribution to conservation. In 40 years, more than 4,300 people from 109 countries have received professional conservation training from the Smithsonian. The exciting opportunity here is that so many people come back to us—or we go to them—later to collaborate on conservation

projects. Untold other individuals and groups work with us and or partners via citizen science efforts.

The Case for Optimism

We must make a case for optimism when facing biodiversity loss. If the public is constantly bombarded with messages about an ongoing biodiversity apocalypse We inadvertently send a message that species are on an inevitable trajectory towards extinction. Doing so without providing solutions risks fostering a sense of helplessness amongst the public who may conclude that nothing they do can make a difference. At the Smithsonian, a team of scientists and curators began to collect stories of what was working all over the world, and discovered many examples of conservation success: in the ocean, on the land, in the coastal intersection between land and sea, in cities, on farms, and in many parts of the U.S. and abroad. We decided to continue to search for stories and to find ways to share them. As a result, we launched **Earth Optimism** in 2017, which reached hundreds of millions of people worldwide—in person through events and online—with stories of conservation success. We partner with farmers, fishers, scholars, thought leaders, students, and organizations from many sectors, to share and curate stories of success. In doing so, we have inspired communities into action. We plan to amplify our message and collaborate with additional organizations to meet our goal of reaching one billion people around the world on the anniversary of Earth Day, 2020.

We can also be optimistic about the emergence of new scientific breakthroughs and technologies like artificial intelligence, machine learning, genomics, remote sensing, and drones—tools that have great potential for helping to achieve positive conservation outcomes.

But one simply cannot conserve or manage wildlife resources remotely using technology alone. The Smithsonian seeks to demystify and democratize access to scientific knowledge and inspire visitors to see themselves as problem solvers and planet-savvy citizens We need to continue educating and training a new generation of people doing the ground-truthing, managing resources, wildlife protection, and mitigation of conflict. . We do this informally through our exhibitions, directly through curriculum developed by the Smithsonian Science Education Center, and at the highest levels through the Smithsonian-Mason School of Conservation. We also engage citizen scientists through citizen science programs, such as Wildlife Insights, whereby volunteers place "camera traps" (infrared-activated cameras) across the landscape in parks and other natural areas to collect photos of wildlife, with more than 6 million photographic images captured to date, which have helped researchers identify nearly 2,000 species and answer critical conservation questions about mammal distribution and abundance worldwide.

Convening for Conservation

The Smithsonian is a convening power—we bring people together and provide a setting where all voices can be heard to discuss some of the planet's toughest challenges and thorniest problems. In my own experience, greater collaboration yields greater results.

The scimitar-horned oryx is a magnificent desert-adapted antelope that once numbered nearly one million animals distributed across the Sahelian grasslands of North Africa. The species was declared "extinct in the wild" in the late 1980s due to over-hunting. Fortunately, large populations of this species were maintained in zoos and private collections, including at the NZP/SCBI. The Smithsonian already had a long history of leadership in understanding and developing husbandry, health, genetic and

reproductive management protocols for this species, when in 2010 we helped to establish a global network of stakeholders interested in reintroducing oryx back into the wild in Chad. Key to our success was engaging the government of Abu Dhabi, which managed large captive herds of oryx, and the government of Chad, which was interested in restoring this species to their historic rangelands. Through this unique partnership, the first oryx were returned to the wild in 2016. Smithsonian scientists continue to monitor the daily movements of these released animals using GPS-enabled tags so that we understand the species' ecology and life-history patterns, as well as the factors associated with either success or failure of this ambitious initiative. The team has a goal of growing the reintroduced herd to more than 500 animals by 2021. Restoring oryx to the wild will have a huge and positive impact on the conservation and management of the entire Sahelian grasslands ecosystem, including for the people who depend upon these ecosystems for their livelihoods. This is an example that demonstrates the value of science, when paired with proper resources, know-how and support from the private sector, to ensure the continued health of our planet, our people and our communities.

We can achieve many more such successes if we move beyond traditional partnerships amongst conservation organizations and government wildlife and natural resource departments. We must adopt new and innovative cross-sectoral approaches to problem solving. This means nature and environment sectors must join other sectors, including infrastructure, energy, health, finance, agriculture, among others. Real win-win solutions will emerge from adopting core environmental principles and increased standards of practice that recognize that integrating conservation into development practice—across multiple sectors—is good for business, good for our families and for every citizen of our country, and for the world.

Another great example at the Smithsonian of such a win-win approach comes from our Tropical Research Institute. The Panama Canal is a massive lifeline of global commerce. In 2010, the canal closed for only the third time in its 100-year history, due to extensive flooding from heavy rains and runoff in the canal zone. Since then, the Smithsonian's Agua Salud Project has been studying how supporting native species and improving agroforestry practices can restore degraded landscapes wile preventing catastrophic water runoff into the canal. In a related story, large commercial ships were routinely striking whales as they entered the Pacific Ocean from the Panama Canal. While catastrophic for the animals, it was also costly and disruptive for global trade. Our scientists tracked whales using GPS-enabled tags to understand their movements and by collaborating with the Canal Authority, this data was used to establish new shipping lanes, and the result has been a 93% reduction in ship-whale collisions. This is an excellent example of how science can be used to solve conservation problems that are win-win for our global economy and for our efforts to save species.

Collaborative, cross-sectoral, and creative problem solving like the examples provided above will be key to meeting this global challenge. Nature needs to be at the decision-making table: not as an interloper, but as an existential partner if it is to fulfill its role in providing its incredible benefits to current and future human societies.

Thank you for the opportunity to testify today on these critical conservation issues. I look forward to answering any questions you may have.

Steven L. Monfort, DVM, PhD
Director, Smithsonian's National Zoo and Conservation Biology Institute

Biography

Dr. Steve Monfort, an international authority in zoo and conservation biology, serves as the Director of the Smithsonian's National Zoo and Conservation Biology Institute. He oversees the National Zoo's collection of more than 1,800 animals, representing 300 species based in Washington, D.C. and the Conservation Biology Institute headquartered on 3,200-acres in Front Royal, VA, where scientists study and breed more than 20 species, including some that were once extinct in the wild. More than 300 National Zoo and Conservation Biology Institute scientists and staff are working to save species by conducting research and training in more than 30 countries worldwide.

Dr. Monfort is a subject matter expert in Zoo Biology, Animal Health, Reproductive Biology, Behavioral Ecology and Conservation Biology. He pioneered noninvasive hormone monitoring techniques that revolutionized assessments of reproduction and stress in wildlife species maintained in zoos and in nature. He has published 150 scientific papers in the broad discipline of reproductive physiology, endocrinology and behavioral ecology, and also was a wildlife veterinary practitioner for 20 years.

As an educator, Dr. Monfort co-founded the Smithsonian-Mason School of Conservation, an in-residence program at SCBI with a mission of "Sustaining global biodiversity by advancing the theory and practice of conservation biology with transformative, transdisciplinary education." The School seeks to provide transformative, hands-on education and professional development in conservation biology and allied fields for undergraduates, graduates, professionals, and others interested in advancing conservation.

As a conservationist, Dr. Monfort is a founder of a number of important conservation initiatives, including: the Sahara Conservation Fund; Conservation Centers for Species Survival; Panama Amphibian Rescue & Conservation Project; and the Global Tiger Initiative. He has served as the chair of the Asian Wild Horse Species Survival Plan, and currently is a member of IUCN's antelope, cervid and conservation breeding specialist groups.

Born in San Diego, California, Steve received a BA in Biology from the U.C. San Diego, doctor of veterinary medicine (1986) and master's (1987) degrees from the U.C. Davis, and doctorate in environmental biology and public policy (1993) from George Mason University.

Chairwoman JOHNSON. Thank you very much. Let me thank all of our witness. And, before we begin our questioning, I'd like to present five documents for the record, letters from the Center for Biological Diversity, and the International Fund for Animal Welfare, and statements from Dr. Jacob Malcolm at Defenders of Wildlife, Dr. Bruce Stein at the National Wildlife Federation, and the National Resources Defense Council. All five documents highlight the shocking and frightening findings of the IPBES report. Further, the letters and statements call for aggressive science-based action to address this crisis. And so, without objection, I'm placing these five documents in the record. At this point we will begin our first round of questions, and I recognize myself for 5 minutes.

Dr. Porter, we appreciate you being here today to talk about the corals as a case study in biodiversity. Your participation is especially timely, since World Reef Awareness Day was just this past Saturday. You mentioned in your testimony that corals are a marine medicine cabinet of sorts, that the unique organisms we find only in coral ecosystems are being used for new drugs that address deadly diseases. Can you talk a little bit more about the health innovations that have resulted from coral so far?

Dr. PORTER. Yes. Thank you, Madam Chairwoman. I can be quite specific about this. A new drug has just been discovered from tropical sea fans called prostaglandin. It's one of the most effective at curing breast cancer. And another drug has just been discovered from a strange marine creature called bryozoan, and that one has been used to cure prostate cancer.

Coral reefs are the oldest environment on Earth, with 400 million years of continuous evolution. And at that point in—with that kind of time, they have evolved chemicals to defend their own territories, and their own lives, and we humans are benefiting from 400 million years of their evolution. Thank you.

Chairwoman JOHNSON. Well, thank you. Are these research activities supported by any Federal grant funding?

Dr. PORTER. Absolutely. All of the Federal agencies that have marine aspects to them are involved, the National Science Foundation, the Environmental Protection Agency. National Oceanic and Atmospheric Administration also has sanctuaries program. And, in addition, funds coming from the Smithsonian have been key. I myself was a pre-doctoral fellow 50 years ago from the Smithsonian, thank you, and that started my career, they are education and research involved in all of those agencies. Their ocean missions must be supported.

Chairwoman JOHNSON. Well, thank you. Now, the pharmaceutical innovators that are already experiencing challenges when they seek to develop new therapies due to the coral bleaching and death, could you explain some on that?

Dr. PORTER. Yes. Corals are a mixture of a plant and an animal. Fifteen percent of the weight of a coral is actually living algae, and this symbiosis is the basis of coral survival. When temperatures rise, the algae are no longer able to photosynthesize, and they leave the coral, and it starves. That's why temperature is so disastrous. We are involved in genetic research, and biochemical research, to understand that intimate linkage.

We know that some corals, over the last 50 years, have developed a tolerance for higher temperatures. This is by the production of heat shock proteins. Those heat shock proteins may indeed help humans survive elevated temperatures. There's active research from all of those agencies on the resistance of corals to rising temperatures, but the scale of the problem—the whole world's oceans are involved—means that we should cut the problem off at its source as soon as we can. Thank you.

Chairwoman JOHNSON. Thank you. Now, Dr. Watson and Dr. Brauman, your report says that biodiversity supports social and mental wellbeing in people, and that biodiversity loss is already having negative effects on our emotional health. Can you comment some on that, both of you?

Dr. WATSON. Yes, thank you. There's no question that people have mental wellbeing when they walk through a forest, when they walk by a river. We also found, in a separate study that I chaired in the United Kingdom, that if you looked at the price of housing that was close to a park, close to river, close to a forest, or woodlands, the price of houses went up quite considerably, basically. So there's lots of evidence that people feel good when they commune with nature, basically. And as we destroy our forests, we destroy our rivers, basically people lose out, and so mental wellbeing is indeed a crucial aspect of one of the benefits we all get from nature.

Dr. BRAUMAN. I'll add that there's really excellent growing research on child development and exposure to nature, that the complexities, and interesting parts of being in nature as a child are very important. The field of study and actually biophysical mental health response to nature exposure is growing, and is certainly an area that's very exciting, and in need of further research.

Chairwoman JOHNSON. Thank you very much, my time has expired. Mr. Lucas.

Mr. LUCAS. Thank you, Madam Chair. Mr. Goodwin, one of the soil health management principles you mentioned is optimize disturbance. You and I both know, but many of our colleagues might not, that prescribed burns, grazing, herbicide applications are actually beneficial for land, if managed correctly. You even point out in your testimony that the Great Plains has lost some of its vast biodiversity because of limiting, or completely removing, fires and grazing. I guess my question is this, when talking about land use, can you explain why actively managing land is more beneficial to the environment and biodiversity than simply letting nature run its course?

Mr. GOODWIN. Yes, sir, and thank you for the question. I think it's important for us to understand the history behind how these ecosystems evolved. When we look at the Great Plains, or southern Great Plains in particular, those systems evolved for thousands of years. The plants, the soils, the animals, all of them evolved under two primary natural disturbances: Grazing (herbivory) and fire. Today our producers manage those two disturbances with prescription. They manage the timing, the intensity, the frequency, the duration of that grazing event, and that prescribed fire, to benefit habitat management for a number of species. For instance, the timing of a prescribed fire might increase—production for both game and non-game grassland bird species. And so understanding, really,

the history behind it, plus also understanding that we need to educate policymakers, and the growing public, on the benefits of both grazing and fire in these systems.

We used to have a fire culture in this country. We used to teach it in grade school. We don't do that anymore. I think we need to understand that—if we understand those two items, then we've moved a long way into the future to helping biodiversity within that system.

Mr. LUCAS. And, Mr. Goodwin, when talking about modern agricultural practices, you refer to this movement as being born out of innovation and economically stable practices. You say specifically that this is not born in a laboratory, or formed by regulatory requirements. There's a fine line between doing things for people and doing things to people. Congress struggles to walk that line sometimes. Why is it important that these practices you discussed in your testimony be driven by producers, and left unimpeded by regulation?

Mr. GOODWIN. I think, just like the diversity that this report is trying to protect, the agricultural landscape is just as diverse. We look across the U.S., we've got extremely diverse soils, we've got different climatic zones, we've got different production systems with different production capabilities. We even apply our practices differently, depending on the location. And so, in short, when we look at farms and ranches, no two are equal. Different soils, different plants, different associations. So these regenerative solutions that were built by principles, they were built on that producer's innate ability to be innovative, and doing things differently on their own, without being asked or forced to.

So as we look at policies that establish a sort of blanket, or one-size-fits-all regulation, we would largely end up with unintended consequences, and ultimately limit our producers freedom to operate, and freedom to innovate.

Mr. LUCAS. Mr. Goodwin, neither you or I are old enough to have been in Oklahoma in the 1930s, in the Great Dust Bowl period, but in your testimony you say producers began to experiment with farming techniques based on equal parts of necessity and frustration. Can you elaborate on those frustrations, the lessons discussed, how we move forward, and compare where we are now on farms and ranches with where our ancestors would have been in the gut of the 1930's, the horrible part of the Dust Bowl, and that period?

Mr. GOODWIN. Certainly. The Dust Bowl was a terrible time. Families were decimated, so was the land. It was the formation of many organizations, mine included, as well as the Soil Conservation Service, as you well know. I think some of the frustrations we face is we need to keep in mind that farmers and ranchers—it's not Hollywood, it's a business. Some are large businesses, some are small businesses, and input costs over the last 60 years have increased to where those producers can't operate the way they once did. They're business owners, and they need to have that ability to look for compelling ways to stay innovative.

Those are some of the ways that have led to those frustrations, and, really, to abandon—they've moved them toward abandoning tradition of the last 60 years, and looking for those compelling re-

generative solutions that help them ecologically and economically, sustainably, provide that food source for the growing public.

Mr. LUCAS. So, essentially, whether it was for the right reason or the wrong reason, nonetheless producers out there have been compelled to adopt a better path?

Mr. GOODWIN. Most certainly.

Mr. LUCAS. Thank you. Yield back, Madam Chair.

Chairwoman JOHNSON. Thank you very much. Mr. Bera.

Mr. BERA. Thank you, Madam Chairwoman. Dr. Monfort, you talked a little bit about the impact of population, and I don't remember the exact numbers you gave, but, you know, clearly our population is rising at a much faster rate than, you know, when we look at history. My other Committee's the Foreign Affairs Committee, and we spend a lot of time thinking about the impact in sub-Saharan Africa, you know, kind of this youth bulge, and, you know, the number of people that are displaced right now not just by war, but by famine, by lack of water, et cetera. And, you know, if you could just maybe expand a little bit on, you know, we all understand the impact of climate change on loss of biodiversity, et cetera, but if you could maybe comment on the impact of, you know, population expansion?

Dr. MONFORT. Well, generally, you know, population expansion means an increased use of resources, or a wiser use of resources. You know, sort of referencing the question earlier, it had to do with, you know, whether we have protected areas, or national parks set aside, and allow them to remain intact, versus what goes on outside the park. And the truth is we live in functionally what you would describe as a landscape mosaic now, where virtually the entire globe is a variety of different land usages. And so we're really in a situation where we need to wisely be able to manage those resources.

If you go back to the example of the oryx, these are nomadic peoples that are using a grassland—a rangeland system, grazing camels and other livestock, and reintroducing oryx is really an effort to introduce land management practices that will allow sustainable use of the ephemeral grasses that will support livelihoods of the people there. So oftentimes it's really about—it is absolutely about better management, better land stewardship, and creating win/wins with the people who depend on biodiversity for their survival.

Mr. BERA. So, as a life scientist—I'm a physician by training—I agree with everything that you're saying. Now, I'm going to do a town hall on Thursday evening, and I'm going to have to explain to my constituents why this is incredibly important. So if each of you could give me a way to put into words that, you know, that mom or dad or who's trying to pay their mortgage, that's trying to get their kids to soccer practice, would take the urgency of, you know, why this is an impact. Maybe starting with Dr. Watson, how I would explain it in a sentence or two to my constituents?

Dr. WATSON. To answer your first question, sir, it's a combination of an increase in population, and a wealthier population, has led to an increase in per capita consumption, and so we need to deal with both of those issues.

But biodiversity fundamentally is not just an environmental issue. Nature has economic value, which we should take account of

in our accounting systems. It also has development value, food, water, energy security, human health. It also is a moral issue, we shouldn't destroy nature, and there's a social issue, as you've heard, that the most disadvantaged of poor people are most adversely affected. So there's multiple reasons we should care about both climate change and biodiversity.

Mr. BERA. Right. Dr. Brauman?

Dr. BRAUMAN. From the very food we eat, to the way we define ourselves, and our sense of place, nature is an incredibly integral part of all of our lives. And when we destroy nature, we really undermine all of those life support systems on which we depend.

Mr. BERA. Great. Dr. Porter?

Dr. PORTER. Yes. Ninety-four countries, half of all nations on Earth, have coral reefs within their boundaries. If we destroy their source of income, and protein, and livelihood, they will be the climate refugees that will move all over the world, and make this place more conflictual.

Mr. BERA. Right. Mr. Goodwin?

Mr. GOODWIN. Yes. I mean, I think it's just important to recognize that nature is important, and we need to do a better job of telling the story of the good things that are happening out on the landscape as well.

Mr. BERA. Great. And Dr. Monfort.

Dr. MONFORT. Yes. Some of these have been said, but ultimately it's about health, and prosperity and security are sort of fundamental policy issues, but if anyone enjoys being in nature, hiking, camping, fishing, hunting, any sort of recreation, they should care about biodiversity.

Mr. BERA. Great. Thank you, and I'll yield back.

Chairwoman JOHNSON. Thank you very much. Mr. Marshall?

Mr. MARSHALL. Thank you so much. I'm one of those people that enjoy being out in nature, and I've always believed that the solutions that rely in sound conservation practices and innovation. I'm a big fan of Ducks Unlimited, Pheasants Forever, Quail Unlimited, the National Wild Turkey Federation, just to name a few that I've been involved with, and the key to all these programs are re-establishing habitat, that we, as hunter and fishermen, know that habitat is absolutely the key to success, and great stories I could share, particularly what Ducks Unlimited has done to re-establish some of the wetlands areas through North America. Mr. Goodwin, do you have any relationships with any of those organizations? I'm kind of shooting from the hip here.

Mr. GOODWIN. Well, I mean, I'm certainly a hunter and a fisherman, enjoy the outdoors, and I'm on the Board of Directors for the Society for Range Management, that promotes habitat management across all of the rangeland. So did you—specifically would you like me to address a question?

Mr. MARSHALL. Not yet. I'll give you a follow up question here. One of the big investigations I went on several years ago was trying to understand the lesser prey chicken, what's kind of happened to its population, and something that might impact part of their rangeland is down in Oklahoma as well. And what I discovered is the best place in the country at re-establishing that habitat actually went back to the way nature was hundreds of years ago, in

that we had buffalo ranging through the Great Plains. They didn't stay in one field, they ranged up and down, north to south, in the season.

So there was grazing practices, and, guess what, there was also natural occurring fires. And the people that are replicating those, establishing that habitat, a little bit of rain is what's really brought back the prairie chicken population. So maybe just give you a little bit more rope to talk about how important it is, maybe tie in some weather reports, national weather reports, how we use those to prescribe fire practices, and how we're using that for even endangered species, like the lesser prairie chicken.

Mr. GOODWIN. Thank you, sir. Yes, and so—when we look at how we manage landscapes from a rangeland perspective, habitat is always in our mind. I mean, this is habitat for numerous terrestrial species, and so I want to look at those management practices that we apply to that landscape. Certainly fire and grazing are important to those, and they're not necessarily just practices. They're ecological processes that helped meld—and helped those processes, and that ecology, evolve.

Specifically, with the lesser prairie chicken, yes, they like those heterogeneous landscapes, so they have their booming grounds. And managing the timing, frequency, intensity, and duration of grazing and fires, how we help that species evolve and sustain itself. And so certainly—and with respect to NOAA (National Oceanic and Atmospheric Administration), and prescribed fire, yes, most certainly we use those data every day. When we employ—or implement a prescribed fire, it's by prescription. We prescribe the weather conditions. We prescribe all of the conditions that—of which we burn, and we ask for a site-specific spot weather forecast. Those data are absolutely invaluable to us, not only form a perspective of planning, but also safety. It helps us document the pre- and post-burn conditions, and, most importantly, it helps us make management decisions on the ground.

Mr. MARSHALL. Exactly. I've done quite a bit of that pasture burning myself. I've often suggested I should sell tickets to let people help me, but that wind report is especially important.

Dr. Porter, you were referring to some biopharmaceuticals, and their use of coral. One of the great things about people in the hunting and fishing realm is that we always work just as hard to leave it better than we found it, and want to go back and work with the habitat to help it be better. What's happening in the world with Big Pharma, whoever's, you know, accessing some of these coral medicines? What are they doing to help refurbish the reefs?

Dr. PORTER. Yes, they have been very active in that. For coral reefs, there is an entire program called bioprospecting, in which animals from coral reefs are being investigated. It turns out the sponges are especially good at giving us new compounds. They have been an ally. I have also worked with Trouts Unlimited exactly for the same reason. They are a force in conservation, and they should be supported. Thank you.

Mr. MARSHALL. Thank you so much. I yield back.

Chairwoman JOHNSON. Thank you so much. Mr. Lamb.

Mr. LAMB. Thank you, Madam Chairwoman. Mr. Goodwin, I wanted to ask you about some of your research into cover crops,

and where you've seen success out where you are. The climate of where I come from, in Western Pennsylvania, is probably pretty different from where you're conducting research. We're seeing an increase in particularly early-season storms, rain storms, very intense, so dealing with a lot of water. Are there crops you've seen in your research that have been especially effective at increasing the biodiversity of the soil when it comes to kind of a wetter environment?

Mr. GOODWIN. Well, Oklahoma and the Southern Great Plains aren't necessarily known to be a wet environment, although I'd argue this year it's pretty wet.

Mr. LAMB. Um-hum.

Mr. GOODWIN. So, you know, I think when we step back, and we look at how we design cover crop mixes, we certainly test the soil. We want to understand what condition that soil is in, and so—and then we tailor cover crop mixes to help us balance carbon and nitrogen ratios to increase not only the species diversity, but—in above ground, you know, biomass, but also rooting structures.

Mr. LAMB. Right.

Mr. GOODWIN. We don't want just tap rooted perennials. We want fibrous root systems, and all those, and those all help us increase soil structure with—it helps us to increase infiltration. We don't have any control over how much rain we get, but we certainly have control over how much we keep, and how much infiltrates into the soil, and recharges aquifers.

Mr. LAMB. So are there certain species that help with that, with the more deeply rooted systems that you're looking for, or——

Mr. GOODWIN. Yes. I mean, we've got forage species, like forage collards, and nitro-radishes, and those sort of species that wildlife do use. They provide flowers for pollinators, and they also have deep taproots that help leave—or help that integration to where we can get infiltration further into the soil profile.

Mr. LAMB. And I'm aware that there is some research going on more widely about whether we can develop new forms of cover crops that will more efficiently store carbon, and sequester carbon at a higher rate than some of the existing ones. Is your organization involved in any of that research, or are you familiar with it? Are you seeing any success in that area?

Mr. GOODWIN. We are. Nobel Research Institute's keenly involved and interested in understanding how we can use cover crops in specific areas. They're a tool. It's not a silver bullet. Certainly, when we look back, and look at how we want to manage for soil health, they're one piece of the pie. Just because I plant cover crops doesn't mean I'm increasing my soil health. I have to manage that crop specifically. But, yes, we're most certainly interested in understanding, again, how that root dynamic adds to carbon sequestration, how do we increase the root's ability to increase the productivity of that plant, but also, how does it attract the diversity of microbes. We learn more and more that more of the organic carbon in the soil is actually microbial bodies, as well as decomposed organic material. So—yes, sir.

Mr. LAMB. Thank you. And, Dr. Brauman, I saw you nodding your head, so if you want to jump in—I'm just curious about specific research efforts that maybe we could look at to try to help fur-

ther along—that maybe involve new species of cover crops, or rediscovered species. Are you familiar with that at all?

Dr. BRAUMAN. Absolutely. There's really interesting research going on at the University of Minnesota, and I would be happy to submit some information about that for the record. One of the things that they've been working on are actually perennial cover crops and perennial food crops. So these are in development, but what we're starting to see are crops that are sort of on the verge of coming to market, like perennial wheat grasses. What that means is that there's not actually a bare period on the soil at all, and especially with these wet springs, which, in the climate forecast, we see much wetter springs in the middle part of the country, as well as drier falls, and so having those crops on the ground is really important.

Nice research at the University of Minnesota. We're seeing really nice cold weather research, which is relevant to Western Pennsylvania, as well as Minnesota, where what we want to make sure is that we don't see, for example, fall applications of fertilizer. Instead, the fertilizer goes on after crops are in the ground, and in multiple iterations so that, when we have wet springs like this, it doesn't all just roll right off the ground.

Mr. LAMB. I see. I read something about a variety of mustard plant that people were trying to create out in California. Are you familiar with that, Mr. Goodwin? Have you——

Mr. GOODWIN. Not——

Mr. LAMB. I think it was a genetically engineered new plant that they thought would add carbon at a higher rate. Just a last technical question, if we ever got to the point where, say, we decided we wanted to try to compensate farmers for growing a certain type of cover crop because it increased, you know, it took carbon out of the atmosphere, is that a technically possible thing to measure? Can you measure how much a farmer has contributed with the crop they use? Go ahead, Dr. Brauman.

Dr. BRAUMAN. Absolutely, and there's research going on at the University of Minnesota on exactly this issue right now. And it's going to be critical—I'm not sure what the situation is for rangeland in Oklahoma, but in Minnesota, sowing cover crops is expensive, and lots of farmers can't afford to do it unless there's a way to monetize that somehow. It's just an extra cost on their shoulders, when it's a benefit to all of us to do it. And so looking for incentives and payments is going to be critical.

Mr. LAMB. Great. Thank you. I yield back.

Chairwoman JOHNSON. Thank you very much. Mr. Baird.

Mr. BAIRD. Thank you, Madam Chair. Mr. Goodwin, I know, and you mentioned, the importance of the land to farmers. And, you know, the scientists at the colleges of agriculture and agriculture extension programs are constantly developing innovations, and looking for better ways to produce more food on less land and water, so one of the things that I see is the new technology, and the equipment that we have today, we're able to more specifically place some of the things that are important to growing a crop, and universities, and the agrobusiness, as well as the extension program, are constantly looking for ways to improve on that. So I

guess my question is would you care to comment on how important that aspect of this research in protecting biodiversity?

Mr. GOODWIN. You know, I think there's always room for technology. We can—anytime that any of us say that we don't have room for improvement, it's a foolish statement. And so certainly we always look for technological solutions, if there are. I think, in this case, that there's certainly room for technological solutions, like new sensor technologies, to help us understand the ecological dynamics that we can't see.

I also think that we need to step back at times and say technology's not always the solution, that we need to work with Mother Nature, and help understand that we can apply these ecologically beneficial practices, and still feed the planet.

Mr. BAIRD. Thank you, Dr. Brauman, you discussed the importance of biodiversity in agriculture. Are there any other crops, besides soybeans, for example, like the work that's being done at Purdue—they are internationally renowned for the work on genetic structures of crop plants like soybeans. So are there any other crops, besides soybeans, that are lacking in biodiversity, and in a need of innovative research?

Dr. BRAUMAN. I can't speak to the specific crops where there's great potential, but what I do know is that there are many crops where this kind of development could be incredibly beneficial. Soybeans had a huge development in the mid century of last century to get them to the productivity point that they're at today, and they're continuing to do that work. We know that, with almost all of the crops we grow, any time we can do innovation, and that ranges from reducing drought sensitivity, to better utilizing nutrients, to simply being better sighted in the places where we're growing them, that we are able to grow food more efficiently with less inputs, and that's always a benefit.

Mr. BAIRD. Thank you. Back to you, Mr. Goodwin. You noted that the Nobel Research Institute (NRI) conducts independent agricultural research similar to our land grant universities. So how does the NRI disseminate its research to the broader agricultural industry?

Mr. GOODWIN. We provide consultation services directly to farmers and ranchers in the southern Great Plains, so we work directly with those producers in an inter-disciplinary approach to provide conservation recommendations based on their goals and objectives, and we also have an extensive educational program. We have thousands of people a year come to the Institute to learn by seeing what exactly we're doing, and how we implement those practices on the 15,000 acres that we own and operate as an Institute. We also certainly publish in popular and scientific journals. Thank you.

Mr. BAIRD. One last quick question. Do you feel this works well for small farmers as well as large agrobusiness, and so on?

Mr. GOODWIN. I think there's a regenerative solution for all size operations. I don't think size is a limiting factor. The limiting factor is, do we think we can do it, and the answer is yes.

Mr. BAIRD. Thank you, and I yield back.

Chairwoman JOHNSON. Thank you very much. Ms. Stevens.

Ms. STEVENS. Thank you, Madam Chair, and thank you to our expert witnesses for joining for today's panel, and congratulations

on the recent report. Certainly quite timely for us, as the Committee on Science convenes to make its mark on how we can protect our biodiversity.

We recently had a hearing in the Subcommittee for Research and Tech on plastics and recycling technologies. I continue to hear from municipalities in my district, suburban Michigan, around the challenges that they're having recycling due to the lack of infrastructure. And, Dr. Brauman, you, in your testimony, referenced plastics pollution, that it's increased tenfold since the 1980s. And I'd like you to just talk a little bit about the urgency that we have in the country to invest in infrastructure to handle the waste that we produce with plastics, and, you know, maybe talk a little bit too about the timeframe that we have in making these investments to revive some of our biodiversity in this country.

Dr. BRAUMAN. Thank you. There's been a huge increase in plastics, and indeed in all kinds of waste, from food waste to waste that does not biodegrade, like plastics, in the United States, and around the world. We see this increase in consumption very clearly in the report. And what that's done is create waste that we then have to do something with, and the need to be able to recycle and reuse these waste products, as well as to simply produce less of them, is critical.

We know that, particularly in the oceans, there's a huge problem with plastic waste, and that there's little that we're able to do about it once it's in the oceans, and so stopping it before it gets there is something that is incredibly important.

Ms. STEVENS. In the oceans and in our food.

Dr. BRAUMAN. Yes. Plastic microbeads is actually a fairly good example of things that people have begun to take out of products, at least in the United States, and so it's clear that we can do something about this when we want to. We are, however, seeing lots of these things everywhere, all around the world, and so making sure that we can reduce consumption, reduce waste, and then also manage waste in better ways is critical, and the sooner we do it, the less we're going to have to clean up later.

Ms. STEVENS. Yes. Great. And—yes, did you want to chime in, Dr. Porter?

Dr. PORTER. Yes, thank you.

Ms. STEVENS. Yes, please.

Dr. PORTER. The estimate now is that by 2050 there will be more plastic in the ocean than fish.

Ms. STEVENS. Yes. Great data point. Thank you. We're not doing it right in the hearing on biodiversity loss and causes if we're not talking about invasive species. I'm also not doing my duty as a Michigander without talking about Asian carp that has created huge problems in the marine ecosystems in the Mississippi River and in Illinois. There's been a long campaign to build the infrastructure to keep Asian carp out of Lake Michigan. Currently there is a $778 million plan to stop the spread of Asian carp to the Great Lakes. The leading edge of the carp population is really, at this point, only 47 miles from Lake Michigan.

And, Dr. Watson, if I could turn to you on this, in your testimony you referenced that invasive species, such as Asian carp, will likely exacerbate some of these trends that are continuing to negatively

impact biodiversity. Where do you believe the Federal Government could rightly partner at the State and local level in investing to make the biggest impact in combating invasive species?

Dr. WATSON. Yes. As our report said, alien invasive species are one of the five direct drivers of loss of biodiversity. And indeed, especially in freshwater systems, such as you've mentioned, one has to take care. The real challenge is to prevent alien invasive species entering our system in the first place. Once you get these species, it's very hard, in many cases, to get rid of them, basically. So I'm not sure what can be done with respect to Asian carp to be honest, our report didn't deal at the subnational level with approaches to dealing with alien invasive species, although Kate may have some better ideas.

Dr. BRAUMAN. Yes. I will say that in Minnesota, we've actually—the northern—the uppermost lock and dam on the Mississippi River is now permanently closed, and so that was, obviously, work that was done with the Army Corps of Engineers in large part to make sure that invasive carp don't actually get above that part of the river. But I absolutely agree with Dr. Watson, we at least know the problems we're facing with the invasive species that are in the country already, and there's no reason to think that future invasive species won't be worse, and so doing a better job keeping those invasive species out is going to be critical.

Ms. STEVENS. It's like a bad horror movie with the carp. Dr. Monfort, I know you were raising——

Dr. MONFORT. Yes——

Ms. STEVENS [continuing]. Your hand, and we actually wanted to get you in on this——

Dr. MONFORT. OK. Sure. I just——

Ms. STEVENS [continuing]. Reference the Smithsonian, and all sorts——

Dr. MONFORT. Right.

Ms. STEVENS [continuing]. Of great programs, so——

Dr. MONFORT. Well, one of the ultimate invasive species has been the chytrid fungus, which is responsible for a global decline in amphibians, and—so studying the origin of these invasions, and tracking them, and understanding how they function is something also that we need to do a better job with.

At the Smithsonian, though, we work with the Coast Guard and—on marine invasive species, and we have the National Ballast Information Clearinghouse System, which is a system that samples ballast water from all ships that are coming into our ports, and we've monitored 550 species of marine and estuarine invertebrates and algae, for example. So this is an example of how you can go about being proactive in monitoring and tracking these organisms and how they're moving.

Ms. STEVENS. Fabulous, thank you. I yield back the remainder of my time.

Chairwoman JOHNSON. Thank you very much. Dr. Babin.

Mr. BABIN. Yes, ma'am. Thank you, Madam Chair. Thank you, everyone, for being here. Appreciate your testimony. Dr. Brauman, I would like to ask you first, I have the honor of serving as the Ranking Member on the Space Subcommittee, as well as getting to represent Johnson Space Center, and I've seen many examples of

NASA's collaborations with private partners to foster innovation and technological growth, from remote sensing robotics to GPS and technologies for growing crops in space, NASA's space exploration and Earth science efforts have yielded remarkable benefits for farms and economic activities and industries. Do you see more collaborative opportunities like these to address the issues that we're discussing today of biodiversity?

Dr. BRAUMAN. Absolutely. I have actually received a grant from NASA last year to run a series of workshops where we brought practitioners, as well as researchers, together to look at better ways to use Earth observations as we assess and do management based on ecosystem services, and it's clear that there's a tremendous opportunity. One of the things that's also very clear is that, in addition to more basic research, we need to be supporting a lot of the background systems that make the kind of information that NASA is developing more accessible to more people. So, if you're an expert, if this is what you do for a living, it's easy to grab their data and do——

Mr. BABIN. Right.

Dr. BRAUMAN [continuing]. Informative things. But it's hard if you're not.

Mr. BABIN. Great. Thank you very much. And, Mr. Goodwin, the threat of pollution on biodiversity in ecosystems is a global issue, and a solution is reliant on the participation of other countries, as well as us. How can we ensure that other countries, big polluters like China and India, are taking the steps toward cleaner solutions, and that the financial burden of tackling global pollution isn't solely on the backs of the American taxpayer?

Mr. GOODWIN. I'd have to say that's out of my wheelhouse. I could speak to the benefits and the good things that our producers here in the United States are doing, but I'm not your guy for China.

Mr. BABIN. OK. But you catch my drift though, right? Well, I'll ask you another one. You mentioned in your testimony many different practices that have increased soil health and productivity. Similarly to my second question, do you see any other countries adopting similar measures? Now, that may be out of your wheelhouse too. And how can we make sure that these other countries are taking steps forward in these areas as well, and that the U.S. is not the only party making these strides?

Mr. GOODWIN. Well, certainly, for soil health management strategies, this revolution is not solely performed in the United States. There are producers, ag producers, all around the world, implementing these principles. And if we focus on the key core soil health building principles—when we look at habitat, and we look at diversity, often we look at it from the top down, and I would submit we need to look at it from the bottom up. We need to——

Mr. BABIN. Right.

Mr. GOODWIN [continuing]. Fix the foundation. Increase the soil health, increase the plant communities. Those plant communities provide the habitat for those wildlife species. Those principles work whether you're in Nairobi, Kenya or in Muskogee, Oklahoma.

Mr. BABIN. Do you believe it should be the role of the American taxpayer, through taxes and regulations, to be responsible for solv-

ing these issues, and do you believe through private partner relationships we can foster innovation and efficiency?

Mr. GOODWIN. I most certainly think there's opportunity for partnerships. I do think it's the role of each individual producer to have the ability and the freedom to operate their producer—or their private property as they need to, and more and more producers are seeing that these ecologically focused principles are benefiting us in both ways, both economically and ecologically.

Mr. BABIN. But is it the American taxpayers' job to solve the problems on global issues?

Mr. GOODWIN. No, sir.

Mr. BABIN. OK.

Mr. GOODWIN. It is not.

Mr. BABIN. All right. And then also, my last question, I represent southeast Texas, which is home to a lot of ag, and it just so happens that my district is, unfortunately, also in a flood prone region with hurricanes. This has created a lot of issues with harvesting and crop production. Can you elaborate a little bit on how some of these new practices could help protect crops and soil during inclement weather and floods?

Mr. GOODWIN. Well, certainly, if we look at the—again, those foundational principles, the first one is keeping the ground covered. We don't want those erosive losses providing further sediment downstream any more than anybody else does.

Mr. BABIN. Right.

Mr. GOODWIN. And so, yes, the principles help us build the ability and the capacity for those soils to hold water back. And so we're going to fix these ecological problems with principles, not just applying practices on the landscape. We have to rethink how we look at it, and look at our practices as a set of tools, and implement those where they need be locally.

Mr. BABIN. Thank you. My time has expired, Madam Chair. Thank you very much.

Chairwoman JOHNSON. Thank you. Mr. Tonko.

Mr. TONKO. Thank you, Madam Chairwoman. Dr. Watson and Dr. Brauman, I would like to pause to get a better picture of how the IPBES conclusions were reached, and what the scientific process looks like in practice. Who wrote this report?

Dr. WATSON. Thank you. First of all, governments around the world scoped the report. In other words, they worked with the science community to say, what were the big scientific policy issues that needed to be addressed? We then had governments and the scientific community nominate experts to write the report. Within IPBES we have a multi-disciplinary expert panel and the bureau. I used to chair the bureau. We then selected scientists from around the world, 150–145, to be precise—who wrote the report. Another 300 scientists around the world helped these 145. Very strong peer review.

We sent out our report to experts and governments around the world twice, and we received 15,000 comments on our report. We responded to all 15,000 comments, and then effectively the governments around the world accept the large report, the 1,700 pages, and then, with the academic community, the lead authors and the co-chairs, we then negotiated the summary for policymakers, the

30-page document, between governments, including the U.S. Government. Over 100 governments participated in Paris, and the lead experts, such as Kate and others. So it's a very open process, incredibly transparent. We published the comments, we will publish all the responses, and it's probably one of the most heavily peer-reviewed documents you will ever find.

Mr. TONKO. OK. And, Dr. Brauman, do you concur with——

Dr. BRAUMAN. Absolutely.

Mr. TONKO. OK. And were any of the authors paid by industry to represent a particular point of view in their participation in the report?

Dr. WATSON. No. Everybody that participates in IPBES, whether they come from academia, such as Kate, whether they come from a government, or a government laboratory, or an NGO (nongovernmental organization), or the private sector, it's absolutely essential they participate in their individual capacity. IPBES has a Conflict of Interest Committee, and we scrutinize every single person that is either an author, a co-author, a review editor, to make sure there is no conflict of interest. I used to chair such the panel.

Mr. TONKO. OK. Well, I thank you both. As someone who deeply respects the scientific process, I'm concerned by some of the attacks on the IPBES conclusions. Recently, during the Natural Resources Committee hearing, some people didn't like the results, and seemed to try to poke holes in the process to get rid of conclusions that didn't suit them. However, anyone who wants to dig deeper can see that this was a rigorous and respectable process. As a Committee, we should play the role of helping to distinguish between false attacks on science and real instances of violations of scientific integrity. There are real examples where science is being suppressed, distorted, or indeed censored, and scientists are being harassed or retaliated against.

I introduced the *Scientific Integrity Act* to ensure that every agency that funds science has strong scientific integrity policies in place. I invite all Members who care about scientific integrity to join me in that effort. I also am equally committed to standing up for good, rigorous, peer-reviewed science. It was recently reported that the Trump Administration is working to change the scope of the National Climate Assessment by cutting off review to 2040. The existing review looks out to 2100 and beyond.

We know that climate impacts have great effect on biodiversity, and we know that, if left unaddressed, climate impacts will get worse in the decades to come. With that in mind, will this new 2040 cutoff limit our understanding of the actual loss of biodiversity?

Dr. WATSON. Yes, without any question. There is a need to look at all plausible futures, out to probably 2100. Climate change is accelerating, and, even with the Paris agreement to try and limit climate change, much of the climate change will still occur after 2040, not only affecting biodiversity, but affecting food security, water security, human health, et cetera. So to try and limit a projection to only 2040 does not make good scientific sense, and it will absolutely harm informed, evidence-based policymaking.

Mr. TONKO. Thank you. And Dr. Brauman?

Dr. BRAUMAN. I'll also note that much of the infrastructure that we build, and indeed many of the decisions we make, we certainly hope are going to last beyond something like 2040. And so, building those to design specifications that take into account what the world is most likely to look like in the future is critical.

Mr. TONKO. So I thank you both for your response to that, and—sure, Dr. Porter.

Dr. PORTER. For coral reefs, the 2040 does not change the assessment at all. All of the things that I've described will occur before 2040.

Mr. TONKO. OK. Thank you very much. With that I yield back, Madam Chair.

Chairwoman JOHNSON. Thank you very much. Mr. Posey.

Mr. POSEY. Thank you, Madam Chair. Among its many concerns, the IPBES report specifically lists a conversion of undeveloped land into farmland as something that we should be particularly concerned about. Obviously we need to continue to feed billions and billions of people, and American agriculture producers lead the world in growing more on less land than ever before. As the world leader in food production, it's not clear to me that we should be concerned about land being converted to farmland. My concern has been, in this country, as well as other parts of the world, we are devoting an increasing amount of land and resources to non-food crops, such as ethanol. Simply put, should we be growing corn for food rather than fuel?

Dr. BRAUMAN. That's a great question. I can tell you what we know about production, and what we know about production is that, globally, we actually produce more than enough calories to feed the world today, and yet there are people that go hungry. And this is very much because we are diverting food crops to non-food uses, or to feed. It's beyond the scope of this report to say the decisions that we should make, but we certainly can talk about what the implications of the decisions that we are making, or that we might make, are, and what we clearly see is that it's the increase in consumption, particularly increasing consumption of meat, that is really driving much of this expansion of farmland at this point, because we do have plenty of farmland, and we do grow crops very efficiently here in the United States.

Mr. POSEY. Thank you. Dr. Watson, I see you writing like crazy.

Dr. WATSON. Yes. I think the challenge is, in many developing countries, to improve the yield per hectare. In many parts of Africa, they're still only getting a ton of produce per hectare, where they should easily be able to get three, four, five tons with more agroecological practices, appropriate use of fertilizers, et cetera.

So, to feed the world, we don't actually have to double food production in the next 30 to 40 years, we have to double the availability of food. We waste 40 percent of all food that's produced in both developed and developing countries—so if we can reduce food waste, it moves us in the right direction, and if we can get rural development in most developing countries, educate the women, who are more often the farmers in developing—make sure they've got some good microfinancing, we could actually not expand our farmland, but increase the productivity of the land and, indeed, copy some of the practices that are common here in the United States.

Mr. POSEY. Mr. Goodwin?

Mr. GOODWIN. Well, I think there's certainly common ground in some of these areas when we talk about land use change, but I'd also say that we already have provisions for some of those in the Farm Bill, with the sodbuster provisions, to reduce some of those activities. But I'd also encourage you that those acres—the rangeland acres are extremely important. They're extremely important at producing habitat, and we graze those with an animal that has the ability to utilize a food source that we can't. We don't eat grass, it does, and it converts that into a very wholesome protein that we do consume. And so we've utilized that grazing as a tool to benefit habitat for both the cow and the wildlife species. So—thank you.

Mr. POSEY. Yes. Again, should we be growing corn for food, rather than fuel? Dr. Porter?

Dr. PORTER. No.

Mr. POSEY. You think we should be doing it for fuel?

Dr. PORTER. When we grow corn, I think it needs to be for food. I think there are other ways to address biofuels without converting corn to it.

Mr. POSEY. Good. Thank you. Dr. Monfort, care to weigh in?

Dr. MONFORT. No. I don't have an opinion on corn.

Mr. POSEY. OK.

Dr. MONFORT. Thank you.

Mr. POSEY. Thank you, Madam Chair. I see my time has expired.

Chairwoman JOHNSON. Thank you very much. Mr. McNerney.

Mr. MCNERNEY. I thank the Chair, and I thank the witnesses. Pretty alarming testimony, folks. But first of all, I'd like to introduce a foster graduate that is tailing me today, and today this is Foster Day, so Erica Hickey, would you please stand up? And we're having a lot of foster youth with the Blue Ribbons today. Please given them some consideration today.

Dr. Brauman, one pathway of achieving transformative change is addressing biodiversity loss by improving freshwater management, protection, and connectivity. California has long been a leader in energy and technology, and now we want to apply that innovation to water modernization in our water systems. The report says that biodiversity is central to water quality and security. Can you expand on that?

Dr. BRAUMAN. Absolutely. So the bottom line for that is that what we put on the landscape ends up in our freshwater, and so having biodiverse watersheds, with functioning ecosystems where we're seeing filtration of water, and regulation of water, as it gets into waterways is critical. Once freshwater is in these rivers, and lakes, and streams, then we also see cycling of nutrients, and lots of other different kinds of potential contaminants by both the plants and animals that are in the freshwater systems themselves. So, altogether, what we see is that these freshwater systems are much healthier when we have active flora and fauna.

Mr. MCNERNEY. I've seen demonstrations in Seattle of road runoff going into systems, and if it just was allowed to sit for a while, it refreshes itself, and fish can live in it. If it's immediate, the fish die, so I think that's a good point.

Dr. Watson, your report says that the biodiversity and conditions that support it also play a role in regulating climate. Would you just say a few words about that?

Dr. WATSON. Well, yes, there's no question about it. If we can keep carbon in a both above and below ground biomass, it effectively stops it getting into the atmosphere. So one of the real challenges is how can we restore degraded ecosystems, how can we reforest degraded ecosystems, and how can we add forest systems with native vegetation? And so if we can manage our land properly, including the soil organic matter, we can actually keep the carbon, or much of the carbon, in soils and in vegetation, rather than in the atmosphere, where it causes human-induced climate change. So there's no question whatsoever, our ecosystems play a key role in managing at least the fluxes of carbon dioxide.

Mr. MCNERNEY. Well, following up on that a little bit, Mr. Goodwin, I'm intrigued by what I'd call carbon farming. Could you describe what that would be, and how it could be profitable?

Mr. GOODWIN. Well, I think when we look at CO_2, or carbon, most of us think about CO_2. There's CO_2 in the atmosphere and the terrestrial vegetation, but there's more in the soil than in both of those combined. And, as a producer, that's where we have our greatest impact. And the term carbon farming is about increasing the organic matter in the soil. And as we increase the organic matter of our soils, we also get these other soil dynamic properties that benefit us from an ecological/functional perspective. And so that's where we gain our inputs, is within the production systems that we currently operate.

Mr. MCNERNEY. Can it be profitable, in your opinion?

Mr. GOODWIN. Most certainly.

Mr. MCNERNEY. So that's a great tool in our fight against climate change, is absorbing carbon into the soils?

Mr. GOODWIN. Yes, sir.

Mr. MCNERNEY. Dr. Monfort, what chances are there of coordinating infrastructure investment and biodiversity planning?

Dr. MONFORT. Well, in terms of biodiversity in the future, it's absolutely essential that there be better coordination across different sectors that have an impact on the environment. Too often what ends up happening are conservation organizations and wildlife departments within governments will talk to one another, but other sectors that are often, especially in the developing world, much more influential or powerful, are not at the table. So, I mean, if you're trying to manage a system, or implement a new policy, and you only have, you know, the poorest wildlife department present, and not the Transportation Ministry, and the Health Ministry, and the economic advisors and so on present, it's unlikely you're going to have good policy come from that.

So solutions really are possible. In our case, we work with oil and gas sector, for example, on doing biodiversity assessments before, during, and after linear pipeline developments, for example. We work with land owners who work—we have a whole program on working land and seascapes where we have our—our scientists are working with large landowners, and trying to understand how can they make money and sustain native biodiversity on their soil, for example, on their property. And a third example involves sus-

taining wildlife in human care. Zoos simply don't have enough room, and so we work with, in Texas, for example, large ranches that private landowners are partnered together in something called conservation centers for species survival. So we recognize that conservation success will only be achieved when you bring in the stakeholders that control most of the resources, and that's governments and private sector entities.

Mr. MCNERNEY. OK. Thank you. I yield back.

Chairwoman JOHNSON. Thank you very much. Mr. Gonzalez.

Mr. GONZALEZ. Thank you, Madam Chair, and to the witnesses for being here today. It's great to hear about the interconnectivity and role that biodiversity plays in our global environment. I was particularly interested to hear about the positive impact that biodiversity has on our economy, encouraging job growth in a variety of fields. One great example happens in my backyard, and that's with respect to the Great Lakes in northeast Ohio. Besides holding 18 percent of the world's freshwater supply, the Great Lakes support more than 1.5 million jobs, and generate $62 billion in wages, much of which is northeast Ohio-based. Great Lakes have produced a $7 billion economic activity return on investment, and it's important for us, as Congress, to continue to invest into resources like the Great Lakes to reduce biodiversity loss.

Dr. Watson, in your testimony you discussed the interconnectivity of biodiversity, and how best practices need to be incentivized worldwide to enact transformative change. Can you discuss how countries can undertake this task while also maintaining steady economic production? For instance, in agriculture, how can farmers overhaul their current process while still maintaining profitability?

Dr. WATSON. Yes. The first thing that we say is we need to be very multi-sectoral. In other words, you can't look at agriculture in isolation of energy, transportation, water, et cetera. So in any government, if we really want sustainable production and use of biodiversity, we need to make sure we get all sectors involved, and all ministers involved. Having finance ministers involved in setting policies that are multi-sectoral. We need to also make sure we get all stakeholders involved. In other words, not just governments, not just the private sector, not just NGOs, but everyone together. We need polycentric governance at all scales.

There is actually no doubt agriculture throughout the world can be much more sustainable. We don't need to extensify. We need to use good agroecological processes, and so there is increased productivity. In my opinion, we can feed the world and save biodiversity, and feed the world in a cost effective way. As I mentioned earlier, reducing food waste is just one factor, but it's basically more than a productivity issue in developing counties, it's rural development. How do you allow the farmer there to develop a productive farm, and actually get their produce to market? So you need roads, you need infrastructure, you need microfinancing.

But the transformative change also says we need to look at our economic structure. GDP is a good measure of economic growth, but it's not a good measure of sustainable economic growth. The World Bank, and many others, talk about the four factors of wealth: Natural capital, human capital, social capital, and built

capital. We need to start to bring into our decisionmaking the value of nature in our decisionmaking, and complement the use of GDP.

Also we need to look, to be quite honest, at some of the large subsidies throughout the world—agricultural, energy, and transportation—that are often very, very harmful to biodiversity. So we need to look at how do you have incentives for sustainable production, and try and eliminate many of these harmful subsidies.

Mr. GONZALEZ. Got you. And then following up, your testimony, you suggest that South America, Asia, and Africa are in the most danger of being affected by biodiversity loss. Can you elaborate on why this is, and whether current policies in North America and European countries have been more effective in combating biodiversity loss? And I realize we're talking about two totally different economies, right? Or three——

Dr. WATSON. Actually, even North America and Europe have not been as successful as we would hope in trying to protect biodiversity. Every country in the world signed up to the so-called—Aichi Targets. There's 20 of them. What we found in our analysis is we're making progress on about four of them. Some of them we've even gone backward in the last 10 years, since the agreement in Japan. The trouble is the loss of biodiversity is the reason that can most affect certain people in developing countries, poor people are more dependent on biodiversity, nature, than we are in, say, North America and Europe, and so many poor people are quite vulnerable to loss of forests, loss of wetlands, loss of grasslands, et cetera.

Mr. GONZALEZ. And then I guess my final question quickly, with the 30 seconds I have, a lot of what you're referring to is happening overseas, outside of our borders. What can we, as the U.S. Government, or what should we be thinking about?

Dr. WATSON. Well, through our aid policies, we can certainly work with developing countries, transfer of knowledge, projects that show how you can be sustainable. So U.S. aid could play a very key role in showing how you could have sustainable agriculture, sustainable energy. All of that would go a long way to making a more sustainable world, and protect biodiversity.

Mr. GONZALEZ. Thank you, and I yield back.

Chairwoman JOHNSON. Thank you very much. Ms. Fletcher.

Mrs. FLETCHER. Thank you very much, Chairwoman Johnson, and Ranking Member Lucas, for holding this hearing. Thank you to the witnesses for your testimony. It has been really interesting. I have jotted down numerous things to share, and I do want to follow up on a couple of questions, but first I have a document that I do want to introduce for the record. The Theodore Roosevelt Conservation Partnership has prepared a statement that outlines what biodiversity loss, climate change, and habitat fragmentation means for hunters and anglers, and I ask unanimous consent to enter the TRCP statement into the record. Thank you, Madam Chairwoman, and that may be a place to start.

Dr. Monfort, we've heard a fair bit today about some of the challenges that wildlife is facing, including disease, invasive species, habitat loss. What resources do you think would be most helpful to Federal and State wildlife managers who are trying to confront the magnitude and complexity of the threat?

Dr. MONFORT. Well, I think knowledge is something that needs to be shared, and, as we learn about new approaches and techniques, we need to make sure that we're sharing those. I mentioned the Virginia Working Landscapes Program that we work in Northern Virginia. Basically, we don't have all the answers at the Smithsonian, but we know that together, collectively, we manage property. Out in our Front Royal facility, for example, we have 3,200 acres, so we're a large land owner and manager. We're trying to learn from each other by sharing knowledge about what works and why, and how we can take things to scale. This is sort of the theme of our Earth Optimism idea, how can we learn from one another to do better, and to find solutions?

And so in a case like that we serve as sort of the intellectual hub. We bring the community together, and we share experiences, and we provide access to external advisors and partners, much like an extension agent might provide. So I think basically boots on the ground, working with people in the communities—in the areas that you're trying to affect change is really important, whether it's here in the U.S., or abroad.

Mrs. FLETCHER. Terrific, thanks. Another topic that we've covered this morning that I'm particularly interested in, because I'm from Houston, so represent a lot of folks down in Houston, where we're dealing with, of course, many of the impacts of climate change, in terms of our weather, in terms of storms, and also as we're confronting our energy future and what it looks like, so we're particularly interested in climate and climate change, and the topic of carbon sequestration is really important. It's one of the things that I think people are looking to. And so I think, Mr. Goodwin, this came up in questions to you about carbon sequestration, and also sort of carbon farming. And I think it also came to you, Dr. Brauman, about is this something we can measure?

So we've heard some innovative and interesting ideas in my district about coming up with a market-based sort of carbon sequestration system that would use, for example, existing wetlands, or preserving native prairie, and I'd love to get your thoughts on some of those kinds of options; how we could measure it, and how we could move from where we are to having a real market-based system that would support that kind of preservation, and increase biodiversity.

Dr. BRAUMAN. So there actually are lots of really exciting models for this. Some of them are called payments for ecosystem services, and they really involve two parts, so one of them is really being able to measure what's the benefit. And there's lots of things we know. I work with the Natural Capital Project. We're doing lots of cool work really quantifying the stuff, and looking at where on the landscape it is. It's something that we need to do more of, but it's something that we know enough to start now.

The other piece that's really important is having the institutional infrastructure to actually make a payment to receive things, and there's really neat models that are beginning to develop everything from water funds, which are becoming more common all around the world. There's some actually here in the United States, where water users are paying upstream residents to manage their lands in different ways to improve water. And what's really great about

the ecosystem services framework is that it lets us plug into a lot of these existing market-based mechanisms.

Mrs. FLETCHER. Terrific, thank you. Mr. Goodwin, do you want to weigh in?

Mr. GOODWIN. Yes, absolutely. Certainly I think there's opportunities for us to look at solutions for incentivizing carbon sequestration and other ecosystem services. The fact is, for thousands of years, producers have been compensated for two ecosystem services, food and fiber, yet they're producing clean water, they're sequestering carbon. I think it's an opportunity for us to not look at the moral sense, but just provide an opportunity for market-based solutions. Not Federal regulation, but instances like the Ecosystem Market Consortium that's currently being put together. They brought together NGOs, they brought together large corporations to find solutions that are providing soil carbon water quality and water quantity solutions for farmers and ranchers.

The problem with the measurement is it's expensive, and so we've look at spectral solutions, like looking at mid-near—mid-vis spectroscopy. So we have to find ways to—and technology's going to help us move in that direction to limit the MRV costs, and—so that we could have more of that money not going back to a middle man, but going back to the producer.

Mrs. FLETCHER. All right. Thank you. I see my time has expired. I thank you, and I yield back.

Chairwoman JOHNSON. Thank you. Mr. Casten.

Mr. CASTEN. Thank you, Chair Johnson. Thank you so much to the panel for being here today. So I often say that climate change is the existential threat to our species, and the IPBES report makes it clear that our species is not particularly unique in the sense of that risk, other than the fact that we think we're unique. With 25 percent of the species at risk, I think we delude ourselves if we think we are not a part of that ecosystem and impacted by it.

Dr. Brauman, I think you said that a 2 degree temperature rise, about 5 percent of the species are at risk, if I was noting that down? Or is that Dr. Watson? OK. I realize this is imprecise, but can I extrapolate from that that about 20 percent of the species loss you see is attributable to climate change, or is that too sloppy an estimate?

Dr. WATSON. I think that problem is all of these drivers, whether it's land use change, pollution, over-exploitation they all interact with each other, and so climate change is one of the threats. It changes species composition, populations. It threatens extinction. It moves the boundaries. So we know that climate change, while it has not been the biggest driver in most systems today, is an increasing driver, so this is why we argue that you have to look at both climate change and loss of biodiversity together——

Mr. CASTEN. Yes.

Dr. WATSON [continuing]. And recognize what are the policies, practices, and technologies that can be win/win for both biodiversity and climate—and not win/lose, because there are some tradeoffs.

Mr. CASTEN. Well, hear hear on that. Let me sort of try to ask the question from a different direction. On the select Committee on

Climate Crisis, we had a panel 2 weeks ago, and I asked them, if we eliminated all CO_2 tomorrow, how much sea level rise is baked in, and the answer was 2 feet. If we eliminated all CO_2 emissions tomorrow, how much species loss is baked in?

Dr. WATSON. To be honest, I can't give you an answer, but we'll try and find an answer for you and submit it to the record. I'll talk to some of the people that will have done some——

Mr. CASTEN. OK.

Dr. WATSON [continuing]. Type of modeling.

Mr. CASTEN. OK. And I'm all for the win/win, and I agree that that's a lot easier, but I want us to be realistic about what we're looking at here going forward, and the consequences.

Mr. Goodwin, I really appreciate all your testimony on agriculture. I come from the energy industry, and I think, in some ways, the energy industry is easy to decarbonize. I think agriculture is much harder, and I appreciate the good work you're doing to get that done. Can you help me understand, what's the range of reasonable carbon reductions we can expect from agriculture? You know, if you look at arable acres of land, or whatever the unit, how many tons per acre can we realistically expect to reduce if we implement all the best practices you've got in mind?

Mr. GOODWIN. Well, I think we start with one farm at a time. I think a lot of times we take this global look, and try to solve the problem globally, when these issues are going to be solved locally. So we start at one farm at a time. And so the key here is to stop making farms on ranches, or employing these practices that provide a source and turning them into a sink, right?

Mr. CASTEN. So I totally agree with that. I ask the question because, as we think about what type of research programs we're going to fund, what types of measures, I'm trying to understand, as my old head of engineering used to say, is it bigger than a breadbox, or is it smaller than a breadbox? What is the potential—and I don't know, Dr. Brauman, if you want to comment on this, because I know you talked about some of this research with perennial crops, how much carbon potential are we talking about that we could sequester in the ag sector? I think we know that number for other sectors. I'm not seeing a really good estimate for what that is in the ag sector.

Dr. BRAUMAN. I think there has been some work done on this, and I don't have that number on me, but I will certainly find it and submit it for the——

Mr. CASTEN. OK.

Dr. BRAUMAN [continuing]. Record. What we do know is that nature is really the only sink for carbon. A lot of that is in the ocean. Some of it's biochemical processes, but it's also about ocean algae, and then what we do on the landscape, which is, you know, growing trees and growing roots, is really the only other place that carbon goes. So in terms of research, and the need to better quantify those numbers, and also find ways to improve them, is critical.

Mr. CASTEN. OK. So I've heard, and I don't know if this is true, I've heard estimates around one to two tons per hectare, but I don't know that that number includes reduced fertilizer inputs, where there's so much CO_2, which brings me back to Mr. Goodwin. When you look at farms that have taken this one farm at a time ap-

proach, presumably they've got fewer inputs, they're getting maybe another, you know, another crop per season out of the land, what is the economic value to that farmer? Is this purely charitable, or does the farmer save money from reduced inputs or higher yields as they go through these practices?

Mr. GOODWIN. Certainly they have increased economic opportunities to decrease the input. A penny saved is a penny earned, right? So if we're not applying those inputs, we've saving money. We've got examples of producers that we work with that are out-yielding their current county cohorts, and their county averages, with limited-to-reduced fertility, and providing sequestered carbon. And that one to two ton number is not out of the question. Certainly not out of the question for a majority of the farms in the United States.

Mr. CASTEN. Well, I see I'm over my time, but I'm delighted that you ended with that, and I swear I didn't set this up. We started and ended with a win/win. Let's stay focused on it. Thank you. I yield back.

Chairwoman JOHNSON. Thank you very much. Ms. Hill.

Ms. HILL. Thank you, Madam Chair. I was just reading a UC Santa Barbara Study last week that quantifies the effects of political lobbying on the likelihood of climate policy enactment. It finds that $700 million in total lobbying by corporations around the Waxman-Markey Bill reduced the bill's chances by 13 percentage points, from 55 percent to 42 percent, representing $60 billion in expected climate damages due to the lowered chance of enacting U.S. climate policy. The money isn't the only cost, of course. Human health and wellbeing are also heavy costs, such as loss of life, and destruction through natural disasters like wildfires.

Last year we saw a number of shocking fires in my home State of California. Two days after election day last November, the Woolsey fire ignited and burned in Los Angeles and Ventura Counties. It destroyed 1,643 structures, killed 3 people, and prompted the evacuation of more than 295,000 people. Throughout California, communities remain devastated and are trying to rebuild today. There's no question that one of the key biodiversity drivers, climate change, is enabling more intense wildfires in the west. While a certain measure of wildfire is "good" for wild areas, so long as people and property can remain safe, in California we're seeing regions staying so dry for so long that it's clear that they are not bouncing back.

Dr. Watson and Dr. Brauman, can you talk a little bit about the relationship between biodiversity and wildfires, and how a changing climate can impact that relationship?

Dr. BRAUMAN. The interaction between biodiversity and wildfires is incredibly complex, and part of the reason is because many of the responses take place over long, but varying timescales. And so the heterogeneity in landscapes that fires produce is great for biodiversity in the long term. We see forest stands, and also grasslands of different ages, with different species. There are many species, especially in California, that actually only regenerate with fire. They need the heat in order for the seedlings to grow.

We also see, in the short term, that there's often devastating effects to biodiversity, both in terms of the vegetation, but also the

animals who are either killed or displaced, and that it can take a very long time for some of that to come back. And one of the reasons that connectivity, thinking about infrastructure, and really thinking about all of these drivers together, is important is that if those animals, if pollen, and seeds, and seedlings have somewhere to go, then the impacts are much less. But if there's only one forest, and it's hemmed in in certain ways, then there's not, and so the impacts can be much greater.

And the other thing that we see is that, with the dryness, and with decreased and—fires, and therefore higher fire intensity, that the impacts are bigger, the impacts are longer, and it's not just on biodiversity, but that's when we start to see really nasty flooding, really bad for water sources, all kind of problems. And so, you know, understanding—putting the time and money in to understand these complex systems and manage them better is critical.

Ms. HILL. Dr. Watson, do you have anything to add?

Dr. WATSON. Not so much on the wildfires, but your first point about vested interests, one thing that we pointed out in our report, and IPCC (Intergovernmental Panel on Climate Change) points out in their's, is that effective actions to have the sort of transformational changes that we need, both to limit climate change and to save biodiversity, there will be some key vested interests that will fight against removing some of these perverse subsidies, against payment for ecosystem services. And so we have to recognize also the power asymmetries between different lobby groups. So your first point is a really crucial one that we brought up in our document, that we need to deal with power symmetries, we need to deal with vested interests, and get everybody on board to see that, in the long term, it's in everybody's best interest to deal with climate change, and to deal with a loss of biodiversity.

Ms. HILL. Absolutely. Should we be addressing wildfires differently than the past given your comments about biodiversity, and how, you know, it's important—in terms of burn areas are important? And also what types—you mentioned the research, that we need to put in the money to understand this, but what types of research are needed, and how do we need to be thinking about funding it?

Dr. BRAUMAN. So there's been a really great evolution in fire management as we have learned more. It's been very responsive to how we understand this, and I am confident that we will continue to evolve our management strategies as we learn more, and so, yes, there will need to be changes. Certainly smaller controlled burns—actually, very similar to the kind of grassland controlled burns that Mr. Goodwin was talking about, are very likely to be important.

Understanding some of the more subtle processes that happen, so things related to soil processes, water, as well as the really kind of big species and big trees issues I think are going to be something that's quite important to understand, especially as these ecosystems regenerate, and we want them to keep delivering the services that are important for us.

Ms. HILL. Thank you so much. I yield back.

Chairwoman JOHNSON. Thank you very much. Dr. Foster.

Mr. FOSTER. Thank you, Chairwoman Johnson, and Ranking Member Lucas, and all of our panelists for joining us. I'd like to

bring up, I guess for not the first time here, the issue of Asian carp, which is very local to my issue. You know, Asian carp have already wreaked environmental havoc up and down the Mississippi River watershed, and it's currently threatening the Great Lakes, and every river connected to them. The last line of defense, actually, is in my district, near the Brandon Road Lock and Dam near Joliet, Illinois. The U.S. Army Corps of Engineers has finalized and approved a proposal of about $778 million which calls for measures such as an engineered channel with an acoustic air bubble curtain and an electric barrier. There's currently a temporary electric barrier in place, which is the best we have.

But not only is this barrier designed to prevent the catastrophic introduction of Asian carp into the Great Lakes, but it's also intended to continue to allow for commercial navigation, which is why it is complicated. And it's now up to Congress to authorize funding for the Army Corps to go ahead with this plan, and, you know, in fact, the WRDA (*Water Resources Development Act*) bill that supports this funding is coming up for a vote this week in the U.S. Congress, and I hope that my Republican and Democratic colleagues come together to vote for the WRDA bill to prevent this catastrophe.

I guess you're already on the record as saying Asian carp are highly destructive. So one of my questions is sort of the longer-term research, and dealing with invasive species. There are ideas out there like gene drives, like the release of sterilized males, which, you know, have been successful in some species. What is your take on that? Are these technologies just ultimately too dangerous to pursue? Are they things that we have to pursue because of the problem with invasive species?

Dr. BRAUMAN. So I'm lucky enough to live further up the Mississippi, where we actually closed one of the locks and dams to keep the invasive carp out. What's clear is that addressing issues of invasive species, once they've already arrived, is always going to be expensive and painful, so the very first thing we need to be paying attention to is managing better to make sure that the invasions and the introductions don't happen in the first place.

Mr. FOSTER. Right. Or we could just send—in the case of Asian carp, just send the bill for all of this to Arkansas, which, in their wisdom, introduced this into ponds that flooded.

Dr. BRAUMAN. In terms of the specifics of the right way to address this, there's a lot of them, and I'm not familiar with the specifics of those, except to say that these kinds of responses are always going to be riskier than simply not introducing these species in the first place. There are a wide range of different kinds of responses. Asian carp are not considered invasive in Asia, and in part because people like to eat them. So, as we change public perceptions, there's all kinds of possibilities out there. But I, again, would really reinforce that being more strategic about making sure that we don't have these kinds of invasions is going to be important.

Mr. FOSTER. Yes. Dr. Watson?

Dr. WATSON. Just in mind a comment I'm not at all an expert on Asian carp, but the next assessment, one of the next big IPBES reports will be on invasive alien species. There will be a whole as-

sessment which will come out in about 2, 2-1/2 years specifically looking at the whole issue of alien invasive species.

Mr. FOSTER. And I hope you also look at countermeasures, and research into countermeasures——

Dr. WATSON. Yes.

Mr. FOSTER [continuing]. Because these things are obviously double-edged swords, but——

Dr. WATSON. Yes.

Mr. FOSTER [continuing]. You know, potentially great and very dangerous. I'd also like to bring up the long-term future of land use for farming. You know, I'm not sure I'm completely on board with the narrative that, you know, there's this ever increasing demand for food and crop land. You know, the population's projected to hit the peak around I think 2070, or sometime like that, and decrease afterwards. Yields on crops like corn have been doubling every 20 years, so that, you know, if you'd only need a certain amount of crop, that will cut by a factor of two the amount of land you need. There are technologies like artificial meat, where, you know, in principle these Impossible Whoppers that are now going to be nationwide at the end of this year, use up I think about one-sixteenth the land per hamburger. And so, you know, it may be that actually, you know, the need for land dedicated to farming will actually peak even earlier than the population, and start declining. I was just wondering if you have, you know, is there anyone who does those sort of projections, and looks at the economic impacts of that?

Dr. BRAUMAN. There are projections along these lines in the IPBES report. We actually looked at a number of scenarios, and some of those involve sustainable futures that include a combination of on-the-ground technologies, as well as reduction in per capita consumption. And so, yes, you're absolutely right, there's lots of potential for not needing to expand farmland as we both change our diets, and also as we increase yields in places where there's lots of opportunity for increasing yields.

Mr. FOSTER. Yes. And, like I say, I haven't even mentioned, you know, these factory farms, in the sense of, you know, growing crops under grow lights, where you can get six crops a year, and don't have the shipping cost to the cities. And it'd be nice to have a forward look at what agriculture looks like 100 years from now so we know what technologies to invest in. And I think I'm over time, and I yield back.

Chairwoman JOHNSON. Thank you, Dr. Foster. Mr. Beyer.

Mr. BEYER. Madam Chair, and Ranking Member Lucas, thank you very much. This is fascinating, especially in light of the UN's report on the accelerated loss of biodiversity. I am very grateful and impressed by the very clear, direct drivers which showed up in a couple of your reports, that changes in land and sea use, direct exploitation of organisms, climate change, pollution, and invasion of alien species. And it's very clear that we're destroying the core of our livelihood—food, health, and economy—and that we're in grave danger.

As a Member of Congress, I'm always struggling for what is it that we can do, what are our direct pieces. Let me quote the wonderful physicist, David Park, who said, "physics is as much a creative mind as it is a body of knowledge. It is the imperative, sim-

plify." To sort of simplify, let me lay out four things. First, on carbon, we know, and I think this Congress will grapple with carbon pricing, some way to make carbon much more expensive, and stimulate everything else, including changes in our behavior. And there are some really good bills. Jerry McNerney, who was up here, has the lead on one of the ones on carbon sequestration. And, once again, there are dozens of experiments around the world right now on taking carbon out of the air, out of the water, out of smokestacks.

I was proud to introduce the *Wildlife Corridors Conservation Act* last week, with Senator Udall and Congressman Vern Buchanan, to ensure it's really to incentivize State and local governments to create corridors so that native wildlife, including fish, animals, plants, butterflies, continue to migrate, adapt, thrive in the face of increasing threats, just to give these species a fighting chance, and it's a critical step forward.

So those are a couple of concrete things, and, by the way, I'd like to ask for unanimous consent to submit a statement from the Wildlands Network on habitat connectivity, without objection. But Dr.——

Chairwoman JOHNSON. Without objection, so ordered.

Mr. BEYER. Thank you. Dr. Watson, Dr. E.O. Wilson, who shows up at some of these, in reacting to Dr. Monfort's notion that we're going to build 15 million new miles of roads by 2050, has talked about half Earth. In fact, his last book is that we should devote half of the terrestrial planet to half Earth. What do you think, and what's the way forward? How do we, as Members of Congress, begin to make that happen?

Dr. WATSON. Yes. We didn't address that directly. We did talk about protected areas. To me, the half Earth concept, I think we'd have to define what you mean by it. People live all over the world today, so the question is how do you integrate people into a protected area? What we did say is that while we've got a lot of protected areas, much of the key biodiversity is not inside our protected areas. Second, many of the protected areas are not well managed, and third, none of the protected area designs take into account climate change as species move, and as boundaries of ecosystems move.

What we pointed out was, yes, we should focus on protected areas, with appropriate design and corridors, but we also have to recognize that much of biodiversity will always lie outside of protected areas, and therefore we have to integrate biodiversity concerns into agriculture, timber, transportation, forestry, et cetera. So it's a combination of how do we do multi-sectoral planning, recognize you don't only think about the economics of a project, or a technology, you think about the implications for biodiversity. So, yes, I think it makes sense to expand the protected areas, both marine and terrestrial, but at the same time, I don't think that you can rely on protected areas alone to really do the job.

Mr. BEYER. OK. Great. Thank you very much.

Dr. MONFORT. May I make a comment on that?

Mr. BEYER. Yes, please, Dr. Monfort.

Dr. MONFORT. Well, first of all, this is the Science Committee, so I'd like to make a plug for science, and the Smithsonian is a knowl-

edge institution. And I would point out that we know very little about biodiversity, and how much there is that exists, and how it's distributed in space and time, and we're discovering new species all the time—the Natural History Museum, every year they discover between 3 to 400 new species every year. There are thousands of species sitting, waiting to be identified, for example, so we know that there's great diversity, but we need to know more.

We don't even know where organisms move. Most organisms that we're trying to save, or we're talking about with biodiversity, we don't even know where they go throughout their life cycle. So we need fundamental knowledge——

Mr. BEYER. OK.

Dr. MONFORT [continuing]. To be able to make good decisions.

Mr. BEYER. All right. Thank you very much. Dr. Brauman, I noticed that you had the Ph.D. in interdisciplinary program and environment and resources. And picking up what Dr. Monfort said about 200,000 years to get to 1 billion people, and 200 more to get to 8 billion, there's incredibly little conversation on Capitol Hill about population, whether it peaks out at 2070 or not. How do we begin to have a responsible conversation on what the carrying capacity of the planet is, especially as it relates not just to water, not just to land, but to biodiversity?

Dr. BRAUMAN. What's critical about the idea of carrying capacity is the question of what does per capita consumption look like? And, with animals that we study, it's not so hard to figure out how much they need to eat, but with people, it turns out that you don't actually drink very much water every day, and yet the amount of water that people need is bigger than that, and varies widely around the world. And so it's almost impossible to have a conversation about carrying capacity without talking about consumption and per capital consumption.

Mr. BEYER. All right. Thank you very much. Madam Chair, I yield back.

Chairwoman JOHNSON. Thank you very much. Ms. Wexton.

Ms. WEXTON. Thank you, Madam Chair, and thank you to the members of the panel for coming out today. I have really enjoyed your testimony, and, although I'm a little bit fearful and frightened about our future, I also feel some optimism about our prospects.

Dr. Monfort, you'll have to excuse me, because I do have to take a moment to engage in a little bit of fangirl action for the National Zoo, and the Conservation Biology Institute. I represent northern Virginia here in Congress, and I am also the mother of 2 kids who are now 14 and 16 years old, but both of them attended zoo camps. We have spent literally thousands of hours, I think, at the National Zoo in one way or another, and we always look forward to that Saturday in fall when we could go to Front Royal and check out the Conservation Biology Institute. What you guys have done with the breeding programs for the scimitar horned oryx and the Przewalski's wild horses is amazing. Although I know you're limited by the genetic stock that you have, what you have managed to do with those populations is incredible.

But I would also note that, while the brush-tailed bettong are very adorable, I would be remiss if I didn't use my opportunity to be speaking with you to express my disappointment that the

Smithsonian no longer—and the National Zoo no longer houses or breeds the black-and-rufous giant elephant shrew. Those were always a fan favorite, and they certainly were mine, but I thank you for everything that you have done, and for your testimony here today.

Dr. Porter, I want to thank you for your passion. It was clear in your presentation how passionately you feel about this, and I was really glad to hear it, because I have a brother who was a non-commissioned officer in the NOAA Corps, so I was glad to see that you participate in some of those NOAA research voyages, and my siblings and I area all SCUBA divers. I think my first checkout dive was about 28 or 29 years ago, and just in that period of time, what I have seen, in terms of the degradation, and the damage to the Caribbean corals, is really frightening and disappointing to me, because I want to be able to take my kids on SCUBA diving trips someday and show them the beauty of the undersea world, and those reefs, and I'm not sure they're going to be there.

So you spoke a lot about the increase in temperature as being the biggest threat, and that——

Dr. PORTER. Yes.

Ms. WEXTON [continuing]. Clearly that's the case, but can you speak a little bit about ocean acidification? Because that's something this Committee is working on at this time, and may be able to hopefully have some good results. I think Ms. Bonamici is back, and she has taken the lead on that. So if you can speak a little bit about acidification, and the impacts that that has as well?

Dr. PORTER. Thank you. CO_2 has two impacts on the ocean. One is to serve as a blanket to raise its temperature, the other is to dissolve into the ocean and acidify it, because CO_2 causes water to be acidic. And I focused on CO_2's problem with temperature because that's the first one that's going to get coral reefs, but the second one is exactly what you said, ocean acidification.

We have a technical term for these two problems in coral reef ecology. They're called the evil twins, and we're worried about both researches going on, thank you for understanding that, and further research on ocean acidification, which is done by all these agencies, is extremely important. Thank you.

Ms. WEXTON. Thank you. Now, my district starts just outside of Washington, D.C., but it does go out pretty far west, into some pretty rural agricultural communities. And I recently met with some farmers in my district, some of whom are starting to implement no till and cover crops to improve their soil quality and soil health. Many of them were also doing this for the first time, so that tells me that there is a new understanding of the need for this, and a desire among agricultural producers to do it. But we don't talk about soil health really just—writ large the same way that we talk about clean air or clean water, but it's just as important, in my mind.

So, in general, Mr. Goodwin, do you think soil carbon health has gotten the right amount of attention in the past, and, if not, what can we do to increase the attention on it?

Mr. GOODWIN. I don't. I certainly think any time we can talk about ecology, and any time we can talk about how carbon works in a system—most people hear CO_2, they're afraid of it, but carbon

is the actual driver in most ecological systems. That's what plants feed on. And so we have to do a better job of telling our story, most certainly, because those producers that are making those changes, they have to believe in it, and when they do believe in it, it takes about 3 years to change practices. To change that practice, I mean, we're talking about changing equipment, everything. And so, once that has been made, in my 20 years of working with producers on the ground, I have yet to meet one producer that's made this significant change, has been successful, and then has gone back to conventional ways.

Ms. WEXTON. Thank you very much. And so it's an issue of convincing them that it's best for them, and for best practices, but then also maybe providing some incentives to make it possible for them to make that transition? Is that correct?

Mr. GOODWIN. Yes, ma'am.

Ms. WEXTON. OK. Thank you very much. I see my time has expired, so I'll yield back.

Chairwoman JOHNSON. Thank you very much. Ms. Bonamici.

Ms. BONAMICI. Thank you very much, Chairwoman Johnson, and Ranking Member Lucas. I'm happy to be able to join you from the Education Committee. The findings of the IPBES Global Assessment are stark. We know that the health of our ecosystems is rapidly deteriorating, and we don't want to get to the point where the consequences will be irreversible. And I'm glad that the report recognizes the multi-coordinated approach to this, and all the drivers of biodiversity loss. I see it as, you know, not only the need to reduce pollution control, invasive species, address the climate crisis, sustainably use our land and water, protect natural habitats—really going to take all of that together.

Dr. Watson, you recently told National Geographic that your biggest personal concern is the state of the oceans. As to co-chair of the House Oceans Caucus, I wanted to call attention to this statement as we recognize National Ocean Month, and Capitol Hill Ocean Week. Our oceans are often left out of the equation when we're responding to the climate crisis, but they're home to most of the life on the planet, and our response to the biodiversity crisis has to put our oceans at the forefront of the solution.

So in your testimony you mentioned that climate change is projected to become as important, or more important, than other drivers of biodiversity loss in the coming decades. Oceans are absorbing more than 90 percent of excess heat trapped in the atmosphere from greenhouse gas emissions, and, of course, causing harmful algal blooms, which produce acid that's harmful to shellfish, like our Oregon Dungeness crab, also may be poisonous to humans, as we know. And as halves decompose, they create the hypoxic dead zones, where marine life cannot survive. So last Congress we authorized the *Harmful Algal Blooms and Hypoxia Research and Control Act*, but hypoxia and harmful algal blooms are often conflated at the Federal level, so I'm working on legislation to address these issues separately. So is there a need or opportunity for dedicated Federal funding for hypoxia mitigation strategies to protect marine species, and what should Congress be doing to support those efforts?

Dr. WATSON. The answer's basically yes to your question, the reason I say that the oceans are a concern, although, I'm concerned about all ecosystems. The concern about the oceans at the moment is we probably spend less attention on the oceans. The plastics in the oceans, we've got to stop it. Most of the plastic is coming from Southeast Asia and the big rivers in Southeast Asia, so we have to worry about the plastics and ocean acidification and the overfishing throughout many parts of the world. The U.S. actually is probably one of the better countries in the world in managing fisheries, but in most parts of the world we're fishing further from shore, deeper into the ocean, smaller and smaller fish, so we have a problem of overexploitation.

Coral reefs, as you've already heard from Dr. Porter, are unbelievably sensitive, not only to climate change, temperature, and ocean acidification at 1.5° C, and we're already at one to 1.1, maybe 10 to 30 percent of corals could survive. At 2° C, probably only 1 percent of corals could survive. And, to be honest, a projection that I made, and actually been supported by much better studies than mine, is we're on a pathway to 3 to 3-1/2 or 4° C. The Paris agreement, which wants us to limit it to 2° C, and even more, 1.5, we're not on a pathway to 1.5 or 2. We're on a pathway of 3 to 4.

Ms. BONAMICI. I'm going to try to get another question in to follow up on what you mentioned about plastics. Every minute the equivalent of a garbage truck full of plastic is dumped into the oceans, according to the UN. It's astounding, eight million tons a year. So I want to talk a little bit about microplastics, and I think this was brought up earlier, but to follow up, we're finding pieces of microplastic in marine life, blocking digestive tracts, altering growth, and in some cases killing animals and marine organisms. We don't know how long it takes for plastic to completely biodegrade. The estimates are, like, 450 years to never. I thank the Committee for getting rid of the plastic bottles. We have cups, we have reusable water bottles, it's a step.

But you're talking about many of the priorities of the bipartisan Oceans Caucus with the fishing and plastics. But I'm working with Senators Whitehouse and Sullivan, and Representative Young, the Oceans Caucus co-chair, on *Save Our Seas 2.0 Act* to take further steps to address marine debris. You're right, a lot of it comes from other places, but it is a global problem. The assessment found that marine plastic pollution has increased tenfold since 1980, affecting at least 267 species, 86 percent of marine turtles, and 44 percent of sea birds, and 43 percent of marine mammals. So what do we currently know about the effects of microplastics on our ecosystem, and what research do we need in the future? Looks like Dr. Porter wants to answer——

Dr. PORTER. Yes.

Ms. BONAMICI [continuing]. That one.

Dr. PORTER. We know very little, which is unfortunate, but we do know that the microplastic particles, after there has been some degradation, are, in fact, more dangerous than the large particles that draw everyone's attention.

Ms. BONAMICI. Right.

Dr. PORTER. As I mentioned earlier, it is estimated that by 2050 there will be more plastic in the ocean than fish. I thank you for your service on the Oceans Committee.

Ms. BONAMICI. Well, thank you. And I see my time has expired. I yield back. Thank you.

Chairwoman JOHNSON. Thank you very much. That's the end of our witnesses, but before we close this hearing I want to thank all of our witnesses for testifying today. You're a superb group.

The record will remain open for 2 weeks for additional statements from Members, or any additional questions the Committee may ask the witnesses. Our witnesses are now excused, and our Committee is adjourned.

[Whereupon, at 12:30 p.m., the Committee was adjourned.]

Appendix I

Answers to Post-Hearing Questions

ANSWERS TO POST-HEARING QUESTIONS

Responses by Dr. James Porter

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

"Nature in Crisis: Biodiversity Loss and its Causes"

Questions for the Record to:

James W. Porter, Ph.D.
Josiah Meigs Professor of Ecology, *Emeritus*
Odum School of Ec9ology
University of Georgia

Submitted by Representative Charlie Crist (FL – 13)

1. In your testimony, you mentioned the coral reefs around Florida and the devastation they are facing. As you know, the tourism and fishing industries in Florida are highly reliant on healthy coral reefs, and their loss would be disastrous.
    a. Can you elaborate on the ecosystem consequences of coral reef death on the communities that rely upon them?
    b. How can states act on their own to be responsible stewards of the coral reefs off their shores to ensure they will exist for future generations?
    c. Can you discuss how chemical ingredients in sunscreens affect corals, and what global governments are doing to address that element of the threat?

Can you elaborate on the ecosystem consequences of coral reef death on the communities that rely upon them?

Response:

Loss of coral reefs will be devastating to the coastal communities that rely on them.

Half a billion people world-wide depend on coral reefs as their sole-source of protein and income. For many communities in the Pacific, coral reefs are also their cultural center. Coral reefs currently generate more than 9.9 trillion U.S.D. annually, most of it in fisheries and hard-currency tourism. Ninety-four sovereign nations on Earth have coral reefs within their territorial boundaries. I predict that the loss of reefs will cause a 50% loss of reef-related revenue.

By the middle of the next century, if sea-level rise continues unabated, at least a dozen sovereign nations will disappear entirely from the face of the Earth. The Indo-Pacific coral-island nation of Kiribati will be the first to go, but will be followed quickly by all of the Caribbean low-island states such as the Bahamas, Curacao and the Turks and Caicos. The Caribbean alone will produce at least 2.5 million environmental refugees fleeing these former tourism power houses. Flight from these formerly successful nation-states will not be an economic preference, but a survival necessity.

Congressman Crist, your question allows me to make a further general prediction, and one which may apply also to the Florida Keys. As rising tropical sea temperatures (by at least 5 °F by 2100) exterminate corals, this will necessitate a shift of coastal economies away from aquatic ecotourism and fin-fisheries toward economies attempting to utilize the algae expected to replace their coral. Whether or not the expected "ecological phase shift," away from the animal-dominated substrates of coral reefs to new plant-dominated substrates, occurs in a manner that permits harvesting these replacement algae is completely unclear. But the inevitability of this

"slippery slope to slime" (as it has been called), suggests that, to survive, the inhabitants of formerly coral-dominated coastlines will be forced to attempt this.

How can states act, on their own, to be responsible stewards of the coral reefs off their shores to ensure they will exist for future generations?

There is a little more optimism in the answer to this question than to the last.

In the short-run, since coral reefs are dependent on LOCAL good water quality, we should:

a. Reduce coastal storm water run-off from roads, parking lots, and commercial areas.
b. Remove all septic and cesspits.
c. Mandate Advanced Wastewater Treatment (AWT) for all residences and businesses.
d. Provide dock-side bilge pump-out stations at all marinas.

As you well know, the Florida Keys has done a marvelous job implementing all four of these. I strongly recommend that the Federal Government help out with these infrastructural improvements, whenever, however, and wherever possible.

In the long-run, since the "800-pound gorilla" in the room causing coral reef decline is Climate Change, local communities should:

a. Demand energy efficiency, especially in lighting and building codes.
b. Promote the use of fuel-efficient vehicles.
c. Support vigorous, rigorous, and effective recycling programs.

Can you discuss how chemical ingredients in sunscreens affect corals, and what global governments are doing to address that element of the threat?

Rapid scientific progress is being made to identify "coral-friendly" sunscreens. Progress is also being made to translate these scientific findings into effective legislation.

The Science:

Twelve of the most-commonly purchased sunscreens were tested, with the following results:

1) **Sunscreens with *oxybenzone*, *avobenzone*, *octocrylene*, and *ecamsule* are bad for corals.**
2) **Sunscreens with *zinc oxide* or *titanium dioxide* do not harm corals*.**

   ***However, zinc or titanium-based sunscreens <u>must</u> be manufactured with non-nano particle zinc and titanium. Otherwise these metals will add small particles to the water. These nano-particles disrupt a coral's ability to feed and clean its surface.**

   Some of the science behind these conclusions is stunning:

   - In addition to the immediate and directly adverse effects on coral of *oxybenzone*, *avobenzone*, *octocrylene*, and *ecamsule*, these four chemicals (and their degradation

products) were found to be "endocrine disrupters," which means they can lower coral reproductive rates – the last thing you want for already stressed organisms!

- *Oxybenzone* is highly toxic to juvenile corals and grossly deforms coral larvae.
- A concentration of as little as 62 parts per trillion of *oxybenzone* is toxic to corals.
- Yet, on certain heavily-visited snorkel reefs in Hawaii, concentrations of *oxybenzone* in the water over the reef were as high as 800 parts per trillion. These concentrations all but assure that on these highly-visited reefs, tourism has reduced coral reproduction there.
- Like DDT, common sunscreen compounds such as *oxybenzone*, *octocrylene*, and *octinoxate* bio-accumulate up the food chain. These compounds have even been found in nesting sea birds near coral reefs.

Legislative response:

Hawaii has taken the lead and banned ***oxybenzone***-based sunscreens. Florida should do the same.

On November 26, 2019 the FDA will release new findings that will provide an updated list of sunscreen ingredients that are "generally recognized as safe and effective," but this list does not address environmental concerns. The FDA list therefore should be compared with the Environmental Working Group (EWG) list of reef-safe sunscreens (as reviewed in Tillmans, F. and A. Uribe. 2019. Sunscreen safety: Learn how to protect yourself and the environment. Alert Diver (Fall, 2019), pp. 56-61. Products that appear on both of these lists then would be safe and effective for both humans and environment.

I strongly recommend that these two lists be consulted to create "sunscreen legislation" for both FL and HI.

Respectfully submitted,

James W. Porter, Ph.D.
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Appendix II

Additional Material for the Record

STATEMENTS SUBMITTED BY REPRESENTATIVE EDDIE BERNICE JOHNSON

June 4, 2019

The Honorable Eddie Bernice Johnson
Chair
Committee on Science, Space & Technology
U.S. House of Representatives
2321 Rayburn House Office Building
Washington, D.C. 20515

The Honorable Frank Lucas
Ranking Member
Committee on Science, Space & Technology
U.S. House of Representatives
394 Ford House Office Building
Washington, D.C. 20515

Dear Chairwoman Johnson and Ranking Member Lucas,

Please accept the follow statement for the record regarding the Committee's June 4 hearing titled "*Nature in Crisis: Biodiversity Loss and its Causes*" that will, among other things, examine the recent scientific report by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). We applaud the Committee for holding this timely hearing and for recognizing the urgent need to act to save the world's biodiversity from extinction.

This landmark global assessment, backed by the United Nations and more than 130 countries around the world, reviewed around 15,000 scientific and government sources and also drew from indigenous and local knowledge. It is the most comprehensive document ever prepared on biodiversity.

The assessment alarmingly concludes that "around 1 million species already face extinction, many within decades, unless action is taken to reduce the intensity of drivers to biodiversity loss."[1] This massive extinction crisis is being driven by climate change, habitat destruction from logging, mining, and farming, direct exploitation of species by poaching, hunting, and overfishing, invasive species, and pollution. Without swift action to reverse these trends, our natural heritage as we know it could disappear forever.

The statistics are sobering. Seventy-five percent of the terrestrial environment and 66 percent of the marine environment have been "severely altered" by human activity. Plastic pollution has increased tenfold since 1980. Fifty percent of agriculture expansion occurred at the expense of forests. Over 40 percent of amphibian species and more than 33 percent of marine mammals are threatened with extinction. The global rate of species extinction "is unprecedented in human history."

[1] S. Diaz, J. Settele, E. Brondizio. 2019. Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services *available at:* https://www.ipbes.net/news/Media-Release-Global-Assessment

Thankfully, the United States arguably has the strongest conservation law in place to help combat the extinction crisis. The Endangered Species Act has not only prevented the extinction of 99 percent of the endangered and threatened animals and plants under its care, but it has put most of these species on the path to recovery. Had the Endangered Species Act not existed, scientists estimate that at least 291 species would have gone extinct since its passage in 1973.[2] These successes are nothing short of a miraculous accomplishment, given that the Act has been severely underfunded for decades, and is a true testament to its effectiveness.

It is undeniable that humans have had a detrimental impact on species all over the world. The downward trend in biodiversity and the ecosystem services that it provides to humanity paints a bleak picture of the future. Without "transformative change"—as the report suggests—the world will continue to lose species at an unprecedented rate. We must take meaningful action before it's too late.

Sincerely,

Stephanie Kurose

Stephanie Kurose
Endangered Species Policy Specialist
Center for Biological Diversity

[2] N. Greenwald, K.F. Suckling, B. Hartl, L. Mehrhoff. 2019. Extinction and the U.S. Endangered Species Act. *PeerJ*7:e6803 *available at*: https://peerj.com/articles/6803/

ifaw

June 4, 2019

The Honorable Eddie Bernice Johnson
Chair
Committee on Science, Space & Technology
U.S. House of Representatives
2321 Rayburn House Office Building
Washington, D.C. 20515

The Honorable Frank Lucas
Ranking Member
Committee on Science, Space & Technology
U.S. House of Representatives
394 Ford House Office Building
Washington, D.C. 20515

Dear Chairwoman Johnson and Ranking Member Lucas:

On behalf of the International Fund for Animal Welfare (IFAW) and our membership across the nation and around the world, thank you for holding today's important hearing, "Nature in Crisis: Biodiversity Loss and its Causes" to examine the recent scientific report on biodiversity by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES).

IFAW has 17 offices globally and works in more than 40 countries around the world. We use fresh thinking and bold action to innovate solutions for tough conservation challenges – including human-wildlife conflicts and illegal wildlife trafficking – that support animals, people, and the place we call home. Recognizing the unbreakable link between animals and human wellbeing, we support and engage with communities, learn from them, and when necessary empower them to coexist with and value native wildlife and companion animals; we also help communities develop tools to protect their natural heritage.

Healthy, biodiverse ecosystems are fundamentally necessary to human health and wellbeing; they provide a bulwark against catastrophic events, increase our resilience, and serve as an insurance policy against future loss. Unfortunately, wildlife and wild lands are in peril around the world. Trafficking in wildlife and wildlife parts remains the fourth most

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lucrative criminal enterprise worldwide. And IPBES has sounded a dire warning with the release of its landmark Global Assessment Report on Biodiversity and Ecosystem Services. The comprehensive report, authored by more than 145 experts from 50 countries over three years, cautions that "1 million animal and plant species are now threatened with extinction, many within decades, more than ever before in human history". This unprecedented threat to biodiversity makes all of us more vulnerable.

However, at IFAW we see reasons for hope. Every day, our global society comes to better understand the complex interconnectedness of human activities with our biosphere. As the IPBES report points out, sometimes our actions have a predictable, direct effect on biodiversity, as in humanity's over-exploitation of species – think the hunting of elephants for ivory, rhinoceros for "medicines" and trinkets, tigers for skins and "medicines", and sharks for fins, for example. In other cases, the effects are secondary, but perhaps no less predictable: land consumption can lead to habitat loss and species decline. Through international cooperative agreements like the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) we have made strides to stem some of the global threats to biodiversity.

Here in the United States, the Endangered Species Act (ESA) remains a cornerstone of conservation that has helped to protect as many as 99% of protected species from extinction, in spite of decades of constrained funding. The ESA, which continues to enjoy strong support from constituents across the nation, recognizes the value of animals and plants to humanity, and has succeeded in steering us on a more balanced path between consumption and conservation.

The IPBES report reminds us that, whatever our successes, we must not be complacent. We urge this committee to meet new and emerging challenges with courage and determination, and with science- based solutions that will enhance conservation objectives, ecosystem resilience, and peaceful coexistence between humans and native wildlife. If we invest wisely now in resilient and sustainable transportation strategies, clean energy, and wildlife-friendly infrastructure, we can make inroads against threats to global biodiversity and preserve healthy ecosystems and wildlife populations for ourselves and for generations to come.

IFAW thanks the Committee for this opportunity to share our thoughts for the record. The IPBES report is a timely call to action: we have only one planet, and human beings must learn that we are only a part of the greater whole. If we cannot coexist with other species, we will not continue to exist at all. But if human behavior can cause great harm to our ecosystems, we are fortunate that so too can considered changes in human behavior begin the healing process. We look forward to working with this committee to ensure a bright future for America, our global neighbors, and this planet we all call home.

Sincerely,

Kate Wall

Senior Legislative Manager

Written Statement of Defenders of Wildlife

Jacob Malcom, PhD
Director, Center for Conservation Innovation
Defenders of Wildlife

before the House Committee on Science, Space, and Technology

June 4, 2019
Hearing on the IPBES Global Assessment of Biodiversity and Ecosystem Services

Chairwoman Bernice Johnson, Ranking Member Lucas and members of the Committee:

For more than 70 years, Defenders of Wildlife has protected and restored imperiled species throughout North America by implementing on-the-ground programs at the state and local level; securing and strengthening state, national and international laws and policies that protect species and their habitats; and upholding legal safeguards for native wildlife in the courts. We represent more than 1.8 million members and supporters across the nation and around the world.

On behalf of Defenders, an organization where the development and application of the best available science guides our work, I appreciate the opportunity to submit a statement for the record to the House Committee on Science, Space, and Technology about the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services' (IPBES) Global Assessment. This seminal report comes at a critical time for wildlife and humanity. Prepared by experts at the top of their fields, the scientific information presented in the report is a stunning, sobering update on the status and trends of global biodiversity. We should all be challenged by its findings:

- One in eight species on Earth—up to one million species—are facing extinction.
- This devastating loss of biodiversity is driven by human alteration of more than 75% of terrestrial environments and 66% of marine environments across the planet.
- Populations of native species have declined by over 20% on average, some much higher. The occurrence of coral reefs globally has declined by 50%.
- Half a trillion dollars of crops are at risk from pollinator loss.
- Half of the international Sustainable Development Goal metrics are declining.

We are losing species faster than ever before in human history, at tens to hundreds of times the pace of the normal background extinction rate. We are facing our planet's sixth mass extinction event. An asteroid striking earth precipitated the last mass extinction, taking out the dinosaurs; this time, we are the cause.

The top threats driving biodiversity loss are all a result of humans living unsustainably—and foremost among them is habitat loss and degradation, both on land and at sea. We have transformed three-quarters of the surface of our planet, causing change that natural systems cannot sustain. The science on biodiversity conservation has long recognized the importance of this threat and identified ways to address it.

The second-greatest threat is our direct exploitation of species. We have hunted, fished, trapped, and in other ways over-harvested species at levels that they cannot sustain. While this threat tends to be less prevalent in the United States, certain groups of species, like plants (for example, orchids), fish, reptiles, and amphibians are susceptible to overexploitation in our country.

And the third-greatest threat—one that nobody can ignore—is climate change. As science has already shown, climate change is radically affecting temperatures, weather, phenology, and biodiversity, causing myriad and negative impacts on species and habitats around the world and in our own backyards. Climate change alone is transforming our planet, but in combination with the other threats, the damage we have done and are doing is almost unimaginable.

Critically, the consequences are as dire for humanity as they are for wildlife under our care. Ecosystem services from crop pollination to fisheries to water filtration and beyond are all at grave risk because of the damage and losses of natural systems.

Despite the darkness of the results, there is reason for hope: we also have solutions. Science is central to identifying and supporting the effectiveness of these solutions.

In the United States, we and wildlife are fortunate to have visionary laws, like the Endangered Species Act (ESA)—the world's most powerful tool for preventing extinction. Like our other bedrock environmental laws, the ESA puts science at the forefront of decision making to help address the challenges identified in the IPBES report. Species listing decisions, federal planning and permitting, and any comprehensive, strategic conservation plans hinge on the use of best available science.

In fact, science supports both the effectiveness and efficiency of the ESA. For example, research Defenders published in the *Proceedings of the National Academies of Science* showed that consultations under the Act—one of the strongest components of the law—allowed almost

every federal action proposed over eight years to proceed while also protecting species. Other research has shown that funding levels are positively correlated with species status—empirical science that leads our advocacy for fully funding the ESA.

And the ESA is just one of our tools for addressing the threats to biodiversity and ecosystem services presented in the IPBES report. Research also points to another, complementary solution: protecting habitat, both terrestrial and marine. For example, the Global Deal for Nature is a science-based proposal that calls for protecting 30% of the Earth's surface by 2030, on global and regional scales, to conserve biodiversity. While perhaps intimidating in its scope, this ambitious policy recommendation provides a roadmap for conserving habitat and biodiversity for our planet and humanity. And as the United States and the world grapple with and address threats to biodiversity and ecosystem services, we have science available to guide our decisions.

We see time and again the importance of science for conserving biodiversity and, as a result, protecting human health and well-being. Science is essential for understanding the state of biodiversity and ecosystem services, as shown in the IPBES report. Science is essential for informing decisions about how to avoid, minimize, and mitigate human-driven harm to species and systems. And science is essential for evaluating the effectiveness of our protections, allowing us to continually improve the effectiveness and efficiency of our actions.

Your constituents, even those who choose to not accept the science, depend on nature and the ecosystem services it provides. We need the leadership of the Committee on Science, Space, and Technology to advocate for science in governing our nation and require the use of science in decision-making. You can help make that difference, not just for wildlife, but for humanity.

NATURE IN CRISIS: BIODIVERSITY LOSS AND ITS CAUSES

House Committee on Science, Space, and Technology

June 4th, 2019
Statement of Dr. Bruce A. Stein
Chief Scientist and Associate Vice President
National Wildlife Federation

The new IPBES report is extremely troubling but not surprising. Over the past few decades, study after study has revealed broad-scale declines in species and natural ecosystems around the world as well as here in the United States. This report synthesizes those findings into a comprehensive, if frightening, assessment of the precarious condition of much of our planet. It also highlights just how dependent—directly and indirectly—we humans are on the services being provided by nature.

The report estimates that as many as one million species worldwide are facing extinction over the next few decades. Based on my more than 30 years of professional involvement in assessing the status and extinction risk of species in the United States and internationally, I consider this to be a conservative estimate. In part this is because the estimate of extinction risk for insect species, an extremely large but poorly known group of organisms, appears to be quite conservative in light of the many recent studies revealing widespread declines in this group (what has been referred to as the "insect apocalypse"). The widespread collapse of monarch butterfly populations in the United States is one illustration of these insect declines. Second, the IPBES report uses an estimate of 8 million species worldwide, of which only about 1.3 million have been scientifically described and named. The total diversity of species on Earth is unknown but estimates vary widely, with most ranging between 5 and 20 million, but with some as high as 100 million. The 8 million figured used in the IPBES estimate is therefore on the low end of this spectrum.

The United States is not immune to the global declines documented in this report. Indeed, based on conservation status assessments conducted by NatureServe and its state government-based network of natural heritage programs, fully one-third of species in the best known groups of plants and animals are vulnerable and at increased risk of extinction. About 150 U.S. species already are presumed extinct, and another 500 or so species have not been seen in recent years and are considered "possibly extinct." The United States has been a leader in the development and application of responsible hunting and fishing regulations, and as a result, unregulated harvest of wildlife is not the same level of problem for species in the United States as IPBES documented globally. Nonetheless, most of the other global threats to biodiversity, ranging from habitat loss and the spread of invasive species to climate change, also threaten U.S. plants and

animals. Indeed, rapid climate change is a "force multiplier" that is exacerbating many of the existing threats to species, and contributing to their declines. The future of wildlife in the United States and around the world increasingly will be linked to our ability to carry out "climate-smart conservation," an approach that National Wildlife Federation has been dedicated to developing and advancing.

The IPBES report makes clear that we are facing twin, linked crises: the biodiversity crisis, characterized by the decline and extinction of species; and the climate crisis, characterized by rapid and accelerating climatic changes that threaten both people and wildlife. Based on the findings of this report, as well as other assessments, including the U.S. National Climate Assessment, it is clear that we must take aggressive action on both biodiversity declines and climate change if we are to maintain a high quality life for Americans now and into the future.

STATEMENT FOR THE RECORD PROVIDED BY THE NATURAL RESOURCES DEFENSE COUNCIL TO THE U.S. HOUSE OF REPRESENTATIVES COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

JUNE 4, 2019

The Natural Resources Defense Council (NRDC) appreciates the opportunity to submit our position on the world's nature crisis as detailed by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) in its Global Assessment on Biodiversity and Ecosystem Services ("Global Nature Assessment"). NRDC also thanks the House Committee on Science, Space, and Technology for holding today's hearing, "Nature in Crisis: Biodiversity Loss and its Causes."

The Global Nature Assessment and other recent reports, such as the Intergovernmental Panel on Climate Change's Special Report: Global Warming of 1.5 °C and the U.S. Global Change Research Program's Fourth National Climate Assessment, lay bare two interrelated crises—climate change and ecosystems collapse—that threaten the natural systems we depend on for life and will cause tremendous human suffering and upend life as we know it if we do not make transformative changes over the next decade.

NRDC is an international nonprofit environmental organization with more than 3 million members and online activists. Since 1970, our lawyers, scientists, and other environmental specialists have worked to protect the world's natural resources, public health, and the environment. While NRDC and the movements it has been a part of for the last fifty years have contributed to significant achievements for the environment and public health, we have never faced crises like those before us today. To retain a natural world that resembles what our ancestors left us and to save the species and natural systems that support human survival, such as pollinators, fish, and healthy soil for food, forests for breathable air, and freshwater for drinking and agriculture, we must firmly break with the policies and approaches of the past.

The stakes have never been higher. According to the Global Nature Assessment, up to a million species are at risk of extinction, many within decades; more than 500,000 species have insufficient habitat for long-term survival, which means they are "committed to extinction" unless we restore their habitats; human activities have severely altered 75 percent of our land environment and 66 percent of the marine environment, putting at risk the ecosystems supporting the air, water, and food humans need to live; land degradation is so harmful that it has reduced agricultural productivity in almost a quarter of our lands; loss of pollinators threaten annual global crop outputs of between $235 billion and $577 billion; 33 percent of fish stocks are overfished and 60 percent are fished at the edge of sustainability; etc.

NATURAL RESOURCES DEFENSE COUNCIL

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Over the next decade, our governments, economies, and resources must be reconfigured to address the major drivers of these losses and threats (changes in land and sea use; direct exploitation of species; climate change; pollution; and invasive species). As the details of that reconfiguration continue to take shape (*e.g.*, how we achieve net-zero global greenhouse gas emissions by 2050), the Global Nature Assessment makes clear that we must start the process of transformative change. Here are some of the things we should be doing now:

- **Protecting vast areas of land and ocean**: to stem the tide of destructive land and ocean alterations, we must fully protect at least 30 percent of the world's land and ocean by 2030.
- **Reducing wasteful practices**: to maintain healthy forests and carbon sinks, we must stop harvesting wild timber.
- **Sustainably feed the world**: to secure access to food, we must improve fishing methods, land use decisions, and farming practices.
- **Safeguard freshwater**: to maintain enough clean water and healthy fish and wildlife populations, we must maximize efficiency, increase storage capacity, improve water quality, and minimize the disruption of our natural water systems, which includes ensuring that existing wetlands and source waters are protected by strong national laws, while preventing industrial and agricultural practices from contaminating our waters.
- **Disrupt current patterns of consumption and waste**: to save biodiversity and reduce pressures on sustainable consumption, we must limit consumption of wildlife to those circumstances where sustainability has been affirmatively demonstrated and we must eliminate wasteful consumption.
- **Uphold keystone environmental laws**: as we look toward a future of new laws that will reconfigure our relationship with nature, we must defend and strengthen existing laws that protect our natural resources, public health, and biodiversity.
- **Eliminate the use of toxic chemicals**: to safeguard human health and critical biodiversity, like pollinators, we must ban the use of toxic chemicals such as neonics.
- **Empower indigenous communities**: to recognize the valuable conservation taking place in indigenous communities, we must recognize the rights of indigenous communities by ensuring that development on their territories has their free, prior, and informed consent.

Actions like these are but a small sampling of the kind of transformative change necessary to address our nature crisis. We thank the Committee for holding this hearing and look forward to working with Congress as it focuses on reversing the harmful trends that are destroying the biodiversity and ecosystems we value and depend upon for human survival.

STATEMENT SUBMITTED BY REPRESENTATIVE LIZZIE FLETCHER

June 3, 2019

The Honorable Eddie Bernice Johnson
Chairwoman
Committee on Science, Space, and Technology
Washington, D.C. 20515

The Honorable Frank Lucas
Ranking Member
Committee on Science, Space, and Technology
Washington, D.C. 20515

Chairwoman Johnson and Ranking Member Lucas,

In advance of the Committee on Science, Space, and Technology's June 4, 2019 hearing titled Nature in Crisis: Biodiversity Loss and it's Causes, the Theodore Roosevelt Conservation Partnership (TRCP) respectfully submits this statement for the record on behalf of America's more than 40 million hunters and anglers. TRCP is a 501 (c)(3) conservation organization dedicated to guaranteeing all Americans a place to hunt and fish. With 59 partner groups representing the nation's leading hunting, fishing, and conservation organizations, TRCP is a leader in conservation policy advocacy and is committed to forging bipartisan solutions to the nation's conservation challenges.

One of the greatest challenges facing America's sportsmen and women is the decline of species and the loss, fragmentation, and degradation of habitats they depend upon through both direct and indirect human actions. Climate change has greatly exacerbated habitat loss and degradation and there is no denying this change is real and has been escalating for the past century. Hunters and anglers have witnessed firsthand the impacts of changing climate and volatile weather patterns that oscillate between the extremes of bone-dry summers and blistering autumns to massive flooding, or winters that are either too warm or too harsh for animals to feed or migrate as they normally would. In the West, large mammals like elk and mule deer stay at higher elevations for longer periods in the fall and their seasonal migrations and breeding seasons have been altered by a changing climate. Fish habitats have been disrupted through declining water quality and quantity and rising temperatures that reduce populations, alter spawning patterns, and ultimately can lead to seasonal fishing closures and changes to season length and harvest limits. Migrations of waterfowl are becoming less predictable, and breeding seasons are disrupted by increasingly volatile weather patterns and habitat loss caused not only by climate change, but suboptimal land and water management. . Compounding these challenges is an onslaught of invasive plant and animal species that generally remain poorly managed in most ecosystems. A rapidly changing climate poses not only a critical threat to biodiversity and ecosystems worldwide, but also creates unique social, political, and management challenges when developing long-term solutions.

Since its inception, TRCP has challenged hunters and anglers to reflect upon the reality that how we choose to act – or not to act – in the face of sharp declines of habitat and biodiversity will have an impact on how future generations enjoy our proud tradition of hunting and fishing. Indeed, we must reflect upon our own actions and take care to invest in the conservation and restoration of our natural resources. Science-based solutions are the foundation of TRCP's advocacy work, encouraging federal, state, and tribal fish and wildlife agencies to comprehensively manage habitats and ecosystems – not just for specific game species, but for all fish and wildlife.

Hunters and anglers know that managing an ecosystem for one species means managing the ecosystem for all its unique flora and fauna, and in doing so, hunters have helped lead the recovery of some of North America's most iconic species. In the early 1900s, had there been legislation like our current Endangered Species Act, species like black bear, wild turkey, white-tailed deer, elk, and pronghorn would have been candidates for protection under the Act. Thanks to the efforts of America's hunters, all of these species have been recovered, are now thriving and managed for sustainable harvest. Similarly, sportsmen and women have been on the frontlines of the century-long fight to reverse wetlands loss and have hence contributed to the recovery of many our nation's migratory bird species. These early successes have become the bedrock of our contemporary system of wildlife management – often referred to as the North American Model – that continues to yield conservation successes in our rapidly changing world.

More recently, sportsmen joined a huge cadre of diverse stakeholders to work with western states and federal agencies to reverse the fate of the greater sage-grouse. While the implementation of state and federal conservation plans is still manifesting and evaluations of their effectiveness ongoing, the planning for conservation of this species and the sagebrush ecosystem – a profoundly biodiverse complex that is home to more than 350 species of plants and animals – has been regarding as one of the greatest efforts in contemporary wildlife management history.

There are myriad of other examples where hunters and anglers banded together to protect the species we pursue and habitats that support them, but they all have one common theme: America's sportsmen and women have been at the forefront of conservation for decades, are mindful of our not only our impact on biodiversity, but also our responsibility and opportunity to help conserve it. . We thank the subcommittee for its attention to the decline of biodiversity and are committed to continuing to work with Congress, the Administration, and our partners across the nation to restore, protect, and preserve our nation's natural resources.

Sincerely,

Whit Fosburgh
President and CEO
Theodore Roosevelt Conservation Partnership

STATEMENT SUBMITTED BY REPRESENTATIVE DON BEYER

Promoting habitat connectivity across the United States is a powerful tool for preventing extinctions and safeguarding biodiversity

Statement for the Committee on Science, Space and Technology

United States House of Representatives

June 4, 2019

Ron Sutherland, PhD, Chief Scientist
Susan Holmes, Federal Policy Director
Katie Davis, Western Wildway Director

Wildlands Network

Introduction

The 2019 Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) report on biodiversity from the United Nations delivered the unfortunate news that up to a million species worldwide are now at risk of extinction. Here in the United States, we also face an extinction crisis, one that is tempered somewhat by our strong Endangered Species Act and our long history of investing in land and water conservation. Nevertheless, far too many species remain on the brink of extinction in this country, including for example the red wolf, tragically down to fewer than 40 individual animals left in the wild. [i]

The forces driving extinction in the United States are the same basic challenges facing species conservation across the rest of the world. Our tremendous biodiversity is under serious threat from habitat loss, habitat fragmentation (breaking what is left of natural habitats into smaller and more isolated pieces), emerging diseases, invasive species, climate change, overharvesting & overfishing, and environmental degradation.

One core strategy for preventing further extinctions in the United States is to focus more efforts on protecting and restoring habitat connectivity

Over 20 years of published scientific research from 180 scientific studies have shown that maintaining habitat connectivity and corridors are critical for the survival of many species [ii] Corridors increase the movement of species between populations by approximately 50% compared to patches that are not connected with corridors[iii] Maintaining or in many cases restoring habitat connectivity can help stabilize or even reverse the impacts of habitat loss and fragmentation, and connectivity is essential for allowing species to adapt to climate change as well. We therefore suggest that improving habitat connectivity should be considered a top priority in this country and across the globe, if we are serious about forestalling the current biodiversity extinction crisis.

How do we enhance connectivity for biodiversity? One common approach is to identify and protect wildlife corridors, which are protected movement pathways that allow animals and plants to migrate or move between two or more specific places. Another way is to protect habitat linkages, which are broader and more generalized areas that provide connectivity at the regional-scale. A third strategy is to mitigate the effects of roads on wildlife movement, since roads and traffic often act as the most significant barriers to terrestrial animals roaming around the landscape. Lastly, connectivity for species that live in the water can often be greatly enhanced by removing or modifying dams or other impediments that would otherwise block fish passage.

How does improving habitat connectivity prevent species extinction?

A well-connected natural landscape provides essential opportunities for species to migrate in response to climate change. In fact, improving habitat connectivity is the strategy most often recommended by scientists for allowing species to adapt to changing climate conditions. This makes sense, as based on what we know, migration is how species have survived historical changing climates for millions of years. The current pace of human-generated climate change is quite fast, and unfortunately at the same time we've broken many landscapes up in such a way that species can no longer move to keep up with their preferred conditions. We need to take immediate steps to reconnect our natural landscapes to enable the massive levels of migration that will be vital to preventing climate-induced extinctions across the United States.

Wildlife corridors and habitat linkages serve a vital role in connecting parks and wildlife refuges that are otherwise too small on their own to maintain viable populations of many species. We have realized in the years since the protection of Yellowstone National Park that even our largest natural protected areas are too small to maintain robust populations of certain wide-ranging mammals, including wolves, grizzly bears, elk, bison, and pronghorn antelope. These animals need tremendous amounts of habitat. For example, grizzly bears and other species have been shown to need the entire Greater Yellowstone Ecosystem to survive, and it is therefore essential to maintain connections between Yellowstone National park and the surrounding national forests. Many of these wide-ranging species have been shown to be "keystones" to the ecosystem. For example, gray wolves are now better appreciated for the vital ecological role they play in and around Yellowstone. The presence of such keystone species helps prevent the extinction of countless other organisms, and only by providing large-scale networks of habitat will we be able to keep them around. Of course, many small-to-medium sized protected areas (such as state parks) around the United States are not adequate by themselves to protect even smaller species of wildlife (such as bobcats, indigo snakes, and box turtles). Maintaining and restoring habitat connections between protected areas is essential to warding off extinction events caused by wildlife populations being too small.

Habitat connectivity at different scales is crucial for allowing animals to make the routine daily, seasonal, annual, and intergenerational migrations that they need to access the resources and conditions that help them survive. For example, pronghorn antelope make an annual migration from the Upper Green River Valley in Wyoming (their low elevation winter range) to Grand Teton National Park (their higher elevation summer range). This "Path of the Pronghorn" is the only federally designated wildlife corridor and perhaps the most famous wildlife corridor in the United States. Protecting the corridor from encroachment by development and roads has become a top priority for ensuring the survival of the antelope into the future. Likewise, monarch butterflies make an incredible multi-generational migration loop around North America, and it is essential to the survival of these beautiful insects that sufficient corridors of appropriate, milkweed-rich vegetation are protected along the way. In the aquatic realm, salmon provide a third well-known example of impressive annual migrations that depend on connectivity. Salmon live in the ocean most of their lives but attempt to return to the upper reaches of rivers to lay their eggs. Dams can block these migrations, devastating salmon populations. However, if fish passage can be restored, healthy salmon runs have returned to many rivers.

Even in situations where species might be otherwise able to survive in isolated populations, we also know that safeguarding habitat connectivity is critical to maintaining healthy levels of genetic exchange. Populations that are too small and isolated can suffer tremendous negative impacts from inbreeding. For example, the Florida panther was stuck in a small area of extreme southern Florida, and years of isolation were leading to serious levels of inbreeding to the point where it seemed inevitable the panther population would go extinct. However, the cats were at least temporally rescued by the addition of a few female mountain lions from Texas. Over the long-term, it will be essential to reestablish connections between panther and mountain lion populations so that healthy levels of genetic exchange can take place. This is true for countless other species as well, including game animals such as deer. No one wants to see their favorite animal populations become isolated and inbred, and therefore increasing habitat connectivity is key.

Mitigating the effects of roads on wildlife is an increasingly well-appreciated solution for enhancing habitat connectivity around the United States. For example, wildlife crossing structures (both underpasses and overpasses) have been proven to almost completely eliminate

road mortality for wildlife when properly sited and installed. This is especially true when wildlife crossings are placed at the critical junctions where wildlife corridors are bisected by major roads. Even if corridors of natural vegetation can be protected and restored across many US landscapes, busy roads will still threaten many species with decline and possibly extinction, unless we greatly increase our efforts to install mitigating solutions across the country.

Protecting wildlife supports the United States economy

Protecting wildlife across the United States is an important component of ensuring a resilient and diversified national economy. Direct economic impacts from various wildlife-related industries are important to overall national GDP and especially important to many rapidly diversifying rural economies across the country. Estimates place the economic contribution of outdoor recreation at $412 billion per year (or 2.2 percent of GDP)[iv], including hunting and angling at over $200 billion per year[v]; bird watching at $41 billion per year.[vi] The economic value of ecosystem services related to wildlife habitat and behavior are hard to quantify, but similarly important to both national economic productivity and quality of life. Protection of wildlife, on an individual, population-level and habitat basis, is necessary to preserve dependent economic and business opportunities and associated standards of living across communities within the United States.

A national approach is needed to protect wildlife corridors

The IPBES Report recognizes the central role that national governments play in conservation and specifically recommends that governments prioritize, "planning ecologically representative **networks of interconnected protected areas** to cover key biodiversity areas."[vii] In the United States, on May 16, 2019, landmark federal legislation to protect wildlife corridors, **The Wildlife Corridor Conservation Act**, was introduced in the House and the Senate. The Act grants authority to key federal agencies to create a National Wildlife Corridor system to on federal public land and creates a Wildlife Movement Grant Program to incentivize the protection of wildlife corridors by states and tribal agencies, as well as private landowners, on non-federal lands. It provides funds for tribes to protect wildlife corridors and creates a scientific database to share wildlife movement information. Passing this bill will provide a most critical tool in our national effort to protect biodiversity and stem extinctions. **Famed Harvard biologist, Dr. E. O. Wilson recently stated, "The Wildlife Corridor Conservation Act would provide the most important step of any single piece of legislation at the present time in enlarging the nations protected areas and thereby saving large swarths of America's wildlife** and other fauna and flora, especially in the critical time of climate change..." [viii]

Across the United States, we are seeing a groundswell of support for protecting wildlife corridors. This year, 12 states including Wyoming, Florida, New Hampshire, Oregon, Maine and Mississippi have introduced bills to protect wildlife corridors and crossings. An ambitious wildlife corridor protection bill recently passed in New Mexico. A public consensus to protect wildlife corridors is beginning to echo the scientific consensus. Although the predictions from the IPBES Report are dire, protecting wildlife corridors is a strategy that can reverse many of these trends and provide hope that we can protect our treasured wildlife for generations to come.

Wildlands Network envisions a world where nature is unbroken, and where humans co-exist in harmony with the land and its wild inhabitants. Our mission is to reconnect, restore, and rewild North America so life in all its diversity can thrive.

Resources for more information:

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Conservation Corridor. A comprehensive website on the science of habitat connectivity maintained by the lab of Dr. Nick Haddad at Michigan State University. https://conservationcorridor.org/

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Wildlands Network - a conservation nonprofit dedicated to reconnecting nature in North America. www.wildlandsnetwork.org

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[i] https://www.fws.gov/southeast/wildlife/mammals/red-wolf/
[ii] Dr. EO Wilson, Harvard University, letter to Congress, May 15, 2019
[iii] Gilbert-Norton L, Wilson R, Stevens J.R. Beard K H 2010. A Meta analytic review of corridor effectiveness, Conservation Biology 24:660-668
[iv] https://www.bea.gov/news/2018/outdoor-recreation-satellite-account-updated-statistics-20122016
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[vi] https://digitalmedia.fws.gov/digital/collection/document/id/1874
[vii] Summary of policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, May 2019, p. 29
[viii] https://wildlandsnetwork.org/blog/wildlife-corridors-conservation-act-press-release-2019/