SOLVING THE CLIMATE CRISIS: NATURAL SOLUTIONS TO CUTTING POLLUTION AND BUILDING RESILIENCE

HEARING

BEFORE THE

SELECT COMMITTEE ON THE CLIMATE CRISIS HOUSE OF REPRESENTATIVES

ONE HUNDRED SIXTEENTH CONGRESS

FIRST SESSION

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SOLVING THE CLIMATE CRISIS: NATURAL SOLUTIONS TO CUTTING POLLUTION AND BUILDING RESILIENCE

TUESDAY, OCTOBER 22, 2019

U.S. HOUSE OF REPRESENTATIVES,
SELECT COMMITTEE ON THE CLIMATE CRISIS,
Washington, DC.

The committee met, pursuant to call, at 2:04 p.m., in Room 1302, Longworth House Office Building, Hon. Kathy Castor [chairwoman of the committee] presiding.

Present: Representatives Castor, Bonamici, Brownley, Huffman, Casten, Neguse, Graves, Palmer, Carter, and Miller.

Ms. CASTOR. The committee will come to order.

Without objection, the chair is authorized to declare a recess of the committee at any time.

Welcome, everyone. Natural climate solutions are ways of storing carbon and avoiding greenhouse gas emissions through conservation, restoration, and improved management of landscapes and wetlands. And today we will examine the potential of natural climate solutions to help meet emissions reduction targets by sequestering carbon in roots and soils and reducing emissions from the land sector by protecting natural resources and natural spaces.

We will also discuss the co-benefits of nature-based climate strategies to create resilient ecosystems and communities from the increasingly severe impacts of climate change.

And I would like to welcome everyone. We have all been quite interested in getting to this topic. So I will recognize myself for 5 minutes for an opening statement.

The climate crisis is a complex problem, and there is no single, easy way to solve it. We have to explore every opportunity we have to keep carbon pollution out of the air and reduce climate risks and the rising cost to people and their communities. Over the past few months, this community has gathered information through hearings and site visits, so that we can build commonsense solutions to the climate crisis. We have examined the transportation sector, the electricity sector, the building sector, the industrial sector. We have discussed the importance of innovation. We have discussed investing in clean energy, rebuilding our infrastructure in a smart way, and creating good jobs in the process.

Today we are switching gears to discuss a powerful solution that is all around us—nature. The world's ecosystems can help us solve the climate crisis. Protecting and restoring our lands and our wa-

terways and our natural spaces can provide a tremendous opportunity to capture and store significant amounts of carbon.

As you will hear from our terrific witnesses today, America's forests, grasslands, wetlands, and agricultural lands can store more carbon. Such carbon sequestration and sinks have the potential to store the equivalent of over one-fifth of the net emissions in the United States every year. And America's farmers are likely to develop solutions for the land that can be shared across the globe.

Nature can help solve other climate change challenges as well. Take wetlands, for example. Whether it is mangroves in Florida or marshes in coastal Louisiana, wetlands are highly effective at storing carbon. They also make our coastal communities more resilient by buffering the impacts and reducing the costs of storm surge, of sea-level rise, and flooding.

Trees are another key natural climate solution. In fact, recent studies show that forests have the greatest potential to mitigate climate change. Trees can also help in the fight for climate justice. It turns out that urban forestry can reduce the effects of urban heat islands, protecting low-income communities from extreme heat.

And investing in better forest management practices to reduce carbon pollution can also help protect communities from destructive wildfires. Oceans, bays, and lakes are helping us store and absorb more carbon, but they are stressed by acidification and warming. We must be mindful not to overload them and trigger ecosystem collapses that would harm everything dependent on them, including us.

Nature offers us plenty of incredible resources to mitigate climate change, but only if we work to protect it. Every 30 seconds our country loses a natural area the size of a football field to human development. When ecosystems are degraded or used for development, the carbon that they store is released into the atmosphere, contributing to a warming climate that will transform the way we live.

On the other hand, when natural spaces and ecosystems are protected and restored, they have the capacity to do incredible things, like filter our air and our water, reduce heat in our cities, and help protect our communities from extreme weather events.

So the choice is clear, protecting nature provides immediate cost-effective opportunities to dramatically reduce emissions and create more resilient communities. Local communities are hungry for a deeper partnership and resources to adapt to the rising cost and impacts of the climate crisis.

So I look forward to hearing from you on the best natural solutions to solve the climate crisis. Thank you all for being here today, and I yield 5 minutes to Mr. Graves, our ranking member.

[The statement of Ms. Castor follows:]

Opening Statement of Chair Kathy Castor
Hearing on "Solving the Climate Crisis: Natural Solutions to Cutting Pollution and Building Resilience"

Select Committee on the Climate Crisis
October 22, 2019

As prepared for delivery

The climate crisis is a complex problem and there is no single, easy way to solve it. We have to explore every opportunity we have to keep carbon pollution out of the air and reduce climate risks and rising costs to people and their communities.

Over the past few months, this committee has gathered information through hearings and site visits so that we can build common-sense solutions to the climate crisis. We've examined the transportation sector, the electricity sector, the industrial sector, and the buildings sector. We've discussed the importance of innovation, investing in clean energy, rebuilding our infrastructure in a smart way, and creating good jobs in the process.

Today, we're switching gears to discuss a powerful solution that's all around us: nature.

The world's ecosystems can help us solve the climate crisis. Protecting and restoring our lands and our waterways—and our natural spaces—can provide a tremendous opportunity to capture and store significant amounts of carbon.

As you'll hear from our witnesses today, America's forests, grasslands, wetlands and agricultural lands can store more carbon. Such carbon sequestration or sinks have the potential to store the equivalent of over one-fifth of the net emissions in the United States every year. America's farmers likely will develop solutions for the land that can be shared across the globe.

Nature also can help solve other climate change challenges. Take wetlands, for example. Whether it's mangroves in Florida, or marshes in coastal Louisiana, wetlands are highly effective at storing carbon. They also make our coastal communities more resilient by buffering the impacts and reducing the costs of storm surge, sea level rise, and flooding.

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When ecosystems are degraded or used for development, the carbon that they store is released into the atmosphere, contributing to a warming climate that will transform the way we live. On the other hand, when natural spaces and ecosystems are protected and restored, they have the capacity to do incredible things, like filter our air and water, reduce heat in our cities, and help protect our communities from extreme weather events.

The choice is clear.

Protecting nature provides immediate, cost-effective opportunities to dramatically reduce emissions and create more resilient communities.

Local communities are hungry for a deeper partnership and resources to adapt to the rising costs and impacts of climate change.

I look forward to hearing from you on the best natural solutions to solve the climate crisis. Thank you for being here today.

Mr. GRAVES. Thank you, Madam Chair, and I want to thank you once again, 2 weeks in a row, for holding a really good, topical hearing. I think this is an issue where we have much opportunity to work together to make a lot of progress.

Madam Chair, you noted that this hearing is all about natural systems, how do we take advantage of our biogenic environment and help to enhance its ability to uptake greenhouse gases.

And I think that it is often an overlooked part of the overall solution, that we need to be maximizing. I think that when you look at the opportunities that we have in our natural systems, to be able to uptake greenhouse gases, it is an extraordinary tool in our tool chest and one that we probably ought to take a fresh look at 45Q and determine how to make tweaks or perhaps do a complementary component. It might be the one provision of the tax bill that my friend, Mr. Huffman, actually supported. But I think that it is an opportunity for us to once again work together.

Madam Chair, as you know, a few lives back I worked on resilience and sustainability for south Louisiana, and back then, we developed one of the first clean development mechanisms in the world—we started before anyone else, and I think ours was really comprehensive—but the first clean development mechanism in the world that actually quantified the uptake of greenhouse gases resulting from our coastal wetlands restoration projects and from preventing the loss of coastal wetlands.

And as we have talked about at previous hearings, by restoring our coastal wetlands and our coastal systems, you complement what also we have talked about here, which is adaptation strategies and using our natural systems to help improve the resilience of our communities. As I think I have said at every hearing we have had, we lost 2,000 square miles of our coast in Louisiana. That is like the State of Rhode Island disappearing. Which means when storms and hurricanes come, we no longer have that buffer. They don't evacuate Arkansas during hurricanes because Louisiana is the buffer. We have lost ours, which means we are more vulnerable to hurricanes. So you get a two-fer. You get the ability to uptake greenhouse gases and sequester those, and you also improve the resiliency of your communities. And I guess a third is the ecological productivity.

So I do think that we have a big opportunity to work together on this topic, as well as a few others that we have discussed in the past.

I am looking forward to hearing the testimony from the esteemed panel today. I had a chance to look over your submitted testimony. I certainly appreciate all of you being here and looking forward to hearing your oral presentation. With that, I yield back.

Ms. CASTOR. Terrific. Without objection, members who wish to enter opening statements have 5 legislative days to do so.

At this time, I want to welcome our terrific witnesses. We have an outstanding panel today. I will go down the line, each of you, and I know Mr. Huffman wants to make a special introduction as well.

First, we have Dr. Joe Fargione—I think that is right, okay—is the lead scientist for The Nature Conservancy's North America region. He is an expert in land use, conservation, and nature's benefits to people, including climate change mitigation.

Our next witness is from Yurok, the Yurok Tribe, whose reservation is located in Mr. Huffman's district, and I will turn it over to you, Mr. Huffman, to introduce him.

Mr. HUFFMAN. Well, thank you very much, Madam Chair. I am really proud to introduce the vice chairman of the Yurok Tribe, Frankie Myers. The Yurok is the largest tribe in California, and it

is also a tribe that is deeply and authentically connected to the beautiful lands of the Klamath River Basin that are its ancestral territory.

Their stewardship of these lands, and especially the forests and the fisheries, has been noted and appreciated by folks all over California, for sure, but their leadership has also been recognized by the United Nations Development Program which gave the Yurok Tribe the Equator Prize, honoring innovative nature-based solutions for tackling climate change, environment, and policy challenges.

I am sure that we have a lot to learn from hearing from hearing from Vice Chairman Myers, and we welcome you to the committee, sir.

Ms. CASTOR. Welcome. Thank you, Mr. Huffman.

Next is Dr. Jennifer Howard. She is the executive chairman—or excuse me—she is the marine climate change director at Conservation International. Her work focuses on protecting coastal and marine ecosystems to mitigate climate change and create resilient coasts and communities.

Next, Mr. Alex Karsner is the executive chairman of Elemental Labs. He is a visiting fellow at the Hoover Institute at Stanford University and a member of the Hoover Institution's energy policy task force. He previously served as DOE's Assistant Secretary for Energy Efficiency and Renewable Energy under President George W. Bush.

Without objection, the witnesses' written statements will be made part of the record.

With that, Dr. Fargione, you are now recognized to give a 5-minute presentation of your testimony.

Thank you.

STATEMENTS OF DR. JOE FARGIONE, LEAD SCIENTIST, NORTH AMERICA, THE NATURE CONSERVANCY; VICE CHAIRMAN FRANKIE MYERS, VICE CHAIRMAN, YUROK TRIBAL COUNCIL, THE YUROK TRIBE; DR. JENNIFER HOWARD, MARINE CLIMATE CHANGE DIRECTOR, CONSERVATION INTERNATIONAL; AND THE HON. ANDY KARSNER, EXECUTIVE CHAIRMAN, ELEMENTAL LABS

STATEMENT OF DR. JOE FARGIONE

Dr. FARGIONE. Chair Castor, Ranking Member Graves, and members of the committee, thank you for inviting me to speak today.

Climate change is no longer a distant threat. We are currently living with its impacts, and our actions now will determine if we can create a world where both people and nature thrive.

The Nature Conservancy is committed to doing our part to tackle climate change by mobilizing action for a clean energy future, accelerating the deployment of natural solutions, and building resilience through natural defenses.

Today I would like to talk to you about the critical role that nature can play in fighting climate change, what I refer to as natural climate solutions. If you remember one thing from my testimony, please remember that we can help fight climate change by planting

trees, promoting soil health, and protecting our wetlands and coastal ecosystems.

These natural climate solutions are affordable, they provide many cobenefits, and they are available now. You may wonder, what does nature have to do with fighting climate change? As you may recall from biology class or at least from watching "Star Trek," life on earth is carbon-based. Plants, for example, are about half carbon. This means that we can help fight climate change by storing more carbon on the landscape in our trees and soils, and by reducing the emissions of carbon dioxide and other greenhouse gases from our natural and working lands.

Last year I led a study with 37 other experts from 22 institutions that assessed the potential for natural climate solutions to reduce emissions in the United States. Our study shows that natural climate solutions can play a significant role in fighting climate change, with a maximum potential benefit equivalent to one-fifth of our Nation's current net emissions. That is the same as if every car and light duty truck in the country stopped emitting carbon. The largest opportunities have to do with planting trees, improved forest management, the avoided conversion of forest and grasslands, and building soil health in our agricultural lands.

Significantly increasing our investments in natural climate solutions, in addition to a rapid transition to more zero carbon energy and energy efficiency, is our best hope for dealing with the climate crisis.

Natural climate solutions not only fight climate change, they provide many other benefits. They clean the air we breathe and the water we drink. They protect our lives and our property from storms and floods. They build soil health, restore forests for recreation and wildlife, and increase the productivity and resilience of our working lands.

For example, investments in cover crops and other conservation practices on farm fields help improve the soil health and water quality, in addition to storing more carbon in the soil.

Improved nutrient management can reduce the cost of fertilizers and save farmers money in addition to reducing emissions of the greenhouse gas nitrous oxide.

Urban reforestation increases people's quality of life and property values and reduces the cooling costs for their homes. And protecting and restoring coastal wetlands can help reduce storm surges and reduce flooding.

Another promising finding of our study is just how affordable many natural climate solutions are. Specifically, there are hundreds of millions of tons of carbon dioxide per year that can be kept out of the atmosphere at just $10 per ton of carbon dioxide or less, well under the price of other technologies that can remove carbon dioxide from the atmosphere. And that is the price just for carbon. All of the other benefits of clean air and water, flood protection, and wildlife are thrown in for free. In short, they are a very good deal.

And while we talk about this as a cost to reduce carbon, for the land owners and producers, this would be revenue. They would be getting paid for reducing pollution and helping provide a stable climate that benefits everyone.

There are many ways to pay for natural climate solutions. Money could come from voluntary payments by companies that want to meet their emissions goals, by providing Federal support directly to land owners and producers such as through existing Farm Bill programs, or from new policies like a price on carbon.

Natural climate solutions are gaining traction, because there are so many good reasons to invest in nature. From reducing costs for farmers and creating jobs for foresters, to improving air quality and protecting coastal communities from flooding, the benefits are numerous.

For all these reasons, the time is right for us to make a significant investment in natural climate solutions. Thank you.

[The statement of Dr. Fargione follows:]

Testimony of Dr. Joseph Fargione
Science Director, North America Region, The Nature Conservancy

Before the U.S. House of Representatives Select Committee on the Climate Crisis
"Solving the Climate Crisis: Natural Solutions to Cutting Pollution and Building Climate Resilience"

October 22, 2019

Chair Castor, Ranking Member Graves, and members of the Committee, thank you for inviting me to testify on natural solutions to cutting pollution and building resilience. I am Joseph Fargione, Science Director for the North America Region of The Nature Conservancy (TNC). Founded in 1951, TNC is a global environmental nonprofit working to create a world where people and nature can thrive. Thanks to more than a million members and the dedicated efforts of our diverse staff and more than 400 scientists, we work in all 50 U.S. states and impact conservation in 72 countries across six continents.

Climate change is no longer a distant threat. We are currently living with its impacts, as Americans are seeing chronic drought, rising seas, record high temperatures, more frequent extreme storms and fires, and significant economic losses (USGCRP 2017). The climate crisis is endangering people, livelihoods, and decades of work on the conservation of America's wildlife and environment.

Addressing climate change is necessary to create a world where both people and nature thrive, where we provide food and goods for our growing population, design healthy and livable cities, and conserve and protect lands, freshwaters, and oceans. To create this world, American innovation and leadership is both capable and necessary.

The Nature Conservancy is committed to tackling climate change and to helping vulnerable people and places deal with the impacts of a changing climate, including increasingly extreme weather conditions. We are doing this by mobilizing action for a clean energy future, accelerating the deployment of natural solutions, and building resilience through natural defenses.

Today, I'd like to talk to you about the critical role nature can play in fighting climate change, what I refer to as Natural Climate Solutions. If you remember one thing from my testimony, remember that we can help fight climate change by planting trees, promoting soil health, and protecting our wetlands and coastal ecosystems. Landowners and producers can be incentivized and rewarded for voluntarily engaging in practices that remove carbon while helping to provide clean water, clean air, and wildlife habitat. If fully realized, Natural Climate Solutions could have a climate benefit up to one fifth of our current net emissions.

You may wonder 'what does nature have to do with fighting climate change?' As you may recall from your biology class, or from watching Star Trek, life on Earth is carbon-based. Plants, for example, are about 50% carbon. The plants on Earth contain almost as much carbon as the atmosphere. And the soil contains nearly 4 times as much carbon as the atmosphere. This means that we can help fight climate change by storing more carbon on the landscape in our trees and soils and by reducing the emission of carbon dioxide and other greenhouse gases from our natural and working lands.

Last year, I led a study, with 37 other experts from 22 institutions that assessed the potential for Natural Climate Solutions to reduce emissions in the United States (Fargione et al. 2018). Our study shows that Natural Climate Solutions can play a significant role in fighting climate change, with the potential benefit equivalent to one fifth of our nation's current net emissions—that's the same as eliminating emissions from all cars and light duty trucks in America. In other words, nature provides much greater potential than most people realize. Significantly increasing our investments in Natural Climate Solutions, *in addition to* increased energy efficiency and a rapid transition to zero-carbon energy sources, is our best hope for dealing with the climate crisis.

Natural Climate Solutions are not a silver bullet—it may be better to think of them as a collection of silver BBs. The largest opportunities include planting trees, improving forest management, avoiding conversion of forests and grasslands, and building soil health in our agricultural lands. Collectively, these efforts can be deployed across hundreds of millions of acres, in every state in our nation. All regions of the country have a role to play in implementing Natural Climate Solutions. Before I describe each Natural Climate Solution in detail, there are several important characteristics of Natural Climate Solutions worth pointing out.

NCS PROVIDE MULTIPLE BENEFITS

Natural Climate Solutions have strong co-benefits. They not only fight climate, they also help provide clean air and water, they improve quality of life, and they help store floodwaters and protect our coasts from storm surges. Further, they build soil health, increasing the productivity and resilience of our working lands. For example, investments in cover crops and other conservation practices on farm fields help improve soil health and water quality, in addition to storing more carbon in the soil. Improved nutrient management can reduce the cost of fertilizer and save farmers money. Urban reforestation increases quality of life and property values and reduces air pollution and mortality from heat waves. Restoring fire-prone forests will reduce the risk of catastrophic wildfires that threaten homes and air quality. And protecting and restoring coastal wetlands can help reduce storm surges, flooding and coastal erosion. Often, it is these other benefits that inspire people to invest in Natural Climate Solutions, and that is a big part of why I think this approach is so promising—because there are so many good reasons to invest.

NCS ARE AFFORDABLE

Natural Climate Solutions are also cost-effective. Specifically, there are hundreds of millions of tonnes of carbon dioxide per year that can be kept out the atmosphere for an investment of just $10 per tonne of carbon dioxide. And that is the price just for the carbon – all of the other benefits of clear air and water, flood protection, and wildlife are thrown in for free. For comparison, the cost of Natural Climate Solutions is well under the price of other technologies that can remove carbon dioxide from the atmosphere (e.g. Keith et al. 2018). While we support continued investments to help drive the commercial deployment of technologies to capture carbon, we know that Natural Climate Solutions are cost-effective today and can be implemented immediately. Therefore, they present an important near-term opportunity to reduce carbon emissions while efforts continue to bring new technologies online.

NCS PROVIDE NEW REVENUE TO FARMERS, RANCHERS AND FORESTERS

While we talk about the 'cost' of reducing carbon through Natural Climate Solutions, for landowners and producers this would be revenue—they would be getting paid for reducing pollution and helping provide a stable climate that benefits everyone. There are many ways to pay for Natural Climate Solutions: funds could come from voluntary payments by companies that want to meet emissions goals; by providing federal support provided directly to landowners and producers, such as through existing Farm Bill programs; or from new policies, like a price on carbon, that create an incentive for payments.

NCS PATHWAYS

Below I describe the specific opportunities that my colleagues and I have identified for the United States (see Figure 1 and Table 1).

Figure 1: Climate mitigation potential of 21 Natural Climate Solutions in the United States. Black lines indicate the 95% confidence interval or reported range. Ecosystem service benefits linked with each Natural Climate Solution are indicated by colored bars for air (filtration), biodiversity (habitat protection or restoration), soil (enrichment), and water (filtration and flood control).

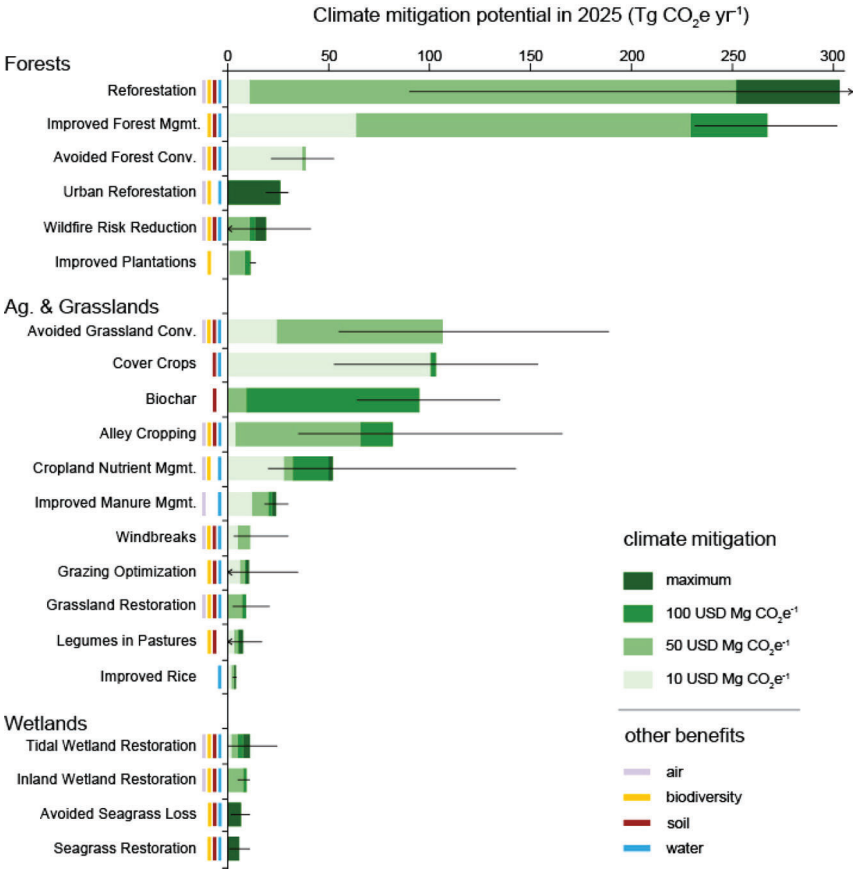

Table 1. Natural Climate Solutions available in the United States. CO_2e refers to the carbon dioxide equivalent, because methane and nitrous oxide are converted to their CO_2 equivalent, in terms of their global warming potential.

NCS Name	Area (Million acres)	Flux (Metric tons CO_2e $acre^{-1}$)	Duration (yr)	Max (Million metric tons CO_2e yr^{-1})	Marginal abatement cost per metric tons of CO_2e $100 (Million metric tons CO_2e yr^{-1})	$50	$10
Reforestation	156	1.97 yr^{-1}	>90	307 (90-777)	252	252	11
Improved Forest Mgmt.	304	0.88 yr^{-1}	25	267 (232-302)	267	229	64
Avoided Forest Conversion	0.94 yr^{-1}	40	>100	38 (22-53)	38	38	37
Urban Reforestation	8	2.82 yr^{-1}	>40	23 (19-30)	0	0	0
Wildfire Risk Reduction	42	0.43 yr^{-1}	>100	18 (-5-42)	13	10	0
Improved Plantation Mgmt.	77	0.16 yr^{-1}	50	12 (11-14)	12	8	1
Avoided Grassland Conversion	1.7 yr^{-1}	62	>100	107 (55-188)	107	107	24
Cover Crops	217	0.47 yr^{-1}	>50	103 (53-154)	103	100	100
Biochar			>100	95 (64-135)	95	9	0
Alley Cropping	37	2.15 yr^{-1}	>50	82 (35-166)	82	66	4
Cropland Nutrient Mgmt.			>100	52 (17-121)	50	32	28
Improved Manure Mgmt.			>100	24 (18-30)	22	20	12
Windbreaks	2	5.28 yr^{-1}	>50	11 (3-30)	11	11	5
Grazing Optimization	131	0.07 yr^{-1}	>100	11 (-13-35)	9	8	6
Grassland Restoration	5.2	1.77 yr^{-1}	>50	9 (3-21)	9	7	0
Legumes in Pastures	14	0.52 yr^{-1}	>100	7 (-3-17)	6	5	3
Improved Rice Mgmt.	3	1.37 yr^{-1}	>100	3.7 (3.2-4.2)	3	3	2
Tidal Wetland Restoration	1	9.94 yr^{-1}	>100	12 (0-24)	7	5	2
Wetland Restoration	7	1.19 yr^{-1}	>100	9 (5-11)	9	7	0
Avoided Seagrass Loss	0.05 yr^{-1}	132	67	7 (2-11)	0	0	0
Seagrass Restoration	4.5	1.32 yr^{-1}	>100	6 (1-11)	0	0	0
Total				1,204 (855-1,644)	1,097	918	299

SPECIFIC NATURAL CLIMATE SOLUTIONS

Reforestation—We identified 156 million acres in the United States that are potentially reforestable. If reforested, these lands would sequester, on average, nearly two tonnes of CO_2 per acre per year, or over 300 million tonnes of CO_2 per year. We first identified all the areas in the United States that used to be forest but have now been converted to some other land use (Hansen et al. 2013). Next, we excluded areas with intensive human development, including all major roads (Open Street Map 2016), impervious surfaces (Xian et al. 2011), and urban areas (U.S. Census Bureau 2015). To eliminate double counting with the wetland restoration pathway, we removed Histosol soils (Soil Survey Staff 2017). To safeguard food production, we removed most cropland and pasture. To estimate the carbon sequestration rate, we used the US Forest Service's estimates for forest growth for each forest type in each region, averaging growth rates over the first twenty years of reforestation (Smith et al. 2006). We discounted the carbon sequestration mitigation benefit in conifer-dominated forests to account for albedo effects. (Conifer-dominated forests are dark and absorb solar radiation, which offsets some of the cooling effect that they provide by sequestering carbon.) The Nature Conservancy and partners are currently analyzing reforestation potential to identify the most feasible opportunities for implementation, such as in floodplains, riparian buffers, burned areas, marginal agricultural lands, and critical wildlife migration corridors.

Natural Forest Management—The maximum mitigation potential of 267 million tonnes of CO_2 per year is based on a "harvest-hiatus" scenario starting in 2025, in which natural forests are shifted to longer harvest rotations. This could be accomplished with less than a 10% reduction in average timber supply (i.e. within the range of historic variation in supply volume) with new timber supplied from thinning treatments for fuel risk reduction until new timber from reforestation is available in 2030. Alternatively, selective harvest practices that remove competing vegetation, reduce "collateral damage" from felling, and stimulate the growth of remaining trees can achieve approximately 60% of the maximum carbon benefits that we identified, with minimal reductions in short term harvest volume (Ellis et al. 2019). The Nature Conservancy and partners are currently piloting these practices in the Central Appalachian region through the Family Forest Carbon Program (https://www.forestfoundation.org/carbon).

Avoided Forest Conversion—We estimate that almost one million acres—940,000 acres—are converted from forest to other land uses in the United States every year, based on the North America Forest Database (Goward et al. 2015). This emits at least 38 million tonnes of CO_2 per year, which could be avoided with better land use planning and incentives to maintain this valuable carbon storage and other ecosystem services that forests provide. Most forest clearing is followed by forest regeneration, rather than conversion to another land use. While remote sensing is good at detecting forest clearing, is not able to predict whether this clearing will be fol-

lowed by conversion to a new land use or whether it will be allowed to regenerate to forest. To estimate the proportion of cleared that that returns to forest, we examined land cleared before 2000 and quantified the proportion that had returned to forest by 2010, in each forest type and region of the United States. We then used these proportions to discount observed rates of forest clearing between 2000 and 2010. We used estimates of avoided carbon emissions from above and below ground biomass that are specific to each region and forest type. We did not count forest loss due to fire to avoid double counting with wildfire risk reduction. We did not count forest loss due to pests because it is unclear whether this loss can be avoided. We reduced the benefit of avoided conversion in conifer-dominated forests to account for their albedo effects. Our results are conservative because they do not count the loss of ongoing sequestration that protected forests would continue to provide. Although rates of carbon sequestration slow over time, available evidence suggests that forests continue to sequester carbon for at least 200 years (Luyssaert et al. 2008).

Urban Reforestation—We found that, across the 3,535 cities in the conterminous United States, roughly 8 million acres of trees could be added (Fargione et al. 2018, Kroeger et al. 2018). We considered the potential for additional street trees and, for those cities not in deserts, we also considered the potential for park and yard tree plantings. The potential percent increase in tree cover was estimated based on high-resolution analysis of 27 cities, which excluded sports fields, golf courses, and lawns (Kroeger et al. 2018). These trees would sequester carbon at a rate of roughly 2.8 tonnes per acre per year (Nowak et al. 2013), or around 23 million tonnes of CO_2 per year. This estimate is conservative in that it only considers the carbon stored in the tree and does not consider any additional benefits of trees. Trees in urban areas have additional co-benefits that are important to consider. For instance, urban trees in the United States already save around 1,200 lives a year during heat waves (McDonald et al. 2019), and many more lives could be saved with additional urban forest canopy. Additional forest canopy would also help clean the air by reducing particulate matter concentrations, reduce electricity consumption during the summer (Akbari et al. 2001, Akbari 2002), and help cities mitigate stormwater and floodwater.

Wildfire Risk Reduction—Prescribed fire and fuel reduction treatments can reduce the risk of high-intensity wildfire, such that that the initial increase in emissions associated with treatment is more than made up for over time by the avoided impacts of wildfires. We considered the effect of prescribed fire treatments on 42 million acres of fire-prone forests in the western United States. Over 20 years, these treatments would avoid emissions of 240 million tonnes of CO_2, an average of 12 million tonnes per year. These treatments also have substantial benefits to society, such as improving water quality and quantity, reducing loss of wildlife habitat, and protecting communities and forest dependent businesses like tourism, recreation and forest products. The impact of wildfires includes both direct emissions from combustion and the suppression of forest growth following wildfires (Collatz et al. 2014, Williams et al. 2016). Investing in targeted controlled burning and selective thinning can achieve long term carbon sequestration while helping to restore forest ecology and reducing the risk of severe wildfires.

Improved Plantations—We quantified the benefits of extending rotation lengths in even-aged, intensively managed wood production forests. Specifically, rotation lengths were extended from current economically optimal rotation length to a biological optimal rotation length in which harvest occurs when stands reach their maximum annual growth. To understand the carbon benefits of extending rotations, imagine if all plantations are harvested when they are twenty years old—the average age of plantations would be ten years. If rotation lengths were extended to forty years, the average age would be twenty years, roughly doubling the amount of carbon on the landscape. These longer rotations grow just as fast and produce just as much, if not more, timber product. However, because the percent increase in capital value slows slightly in later years, there would be some economic cost to plantation owners, which could be compensated for via carbon payments.

Avoided Conversion of Grassland—Conversion of grassland to cropland emits about 62 tonnes of CO_2 per acre. Most of this is from soil carbon, which we estimate is reduced by 28% down to 1 meter after conversion to cropland (Sanderman et al. 2017). Additionally, there is a loss of root biomass when grasslands are converted to cropland: annual crops don't store carbon long-term in roots, whereas grasslands have about 4 times as much root biomass as they do aboveground biomass (Mokany et al. 2006). About 81% of emissions are from the soil, and 19% from root biomass. The conversion of grassland to cropland is an ongoing issue in the United States. While the total amount of cropland in the United States fluctuates slightly with commodity prices, it is not going up in the long term. However, loss of farmland to development and urban sprawl (Sorensen et al. 2018) spurs the expansion of crop-

land into areas that are more marginal for crop production such as native rangeland (World Wildlife Fund 2018). Between 2008 and 2012, about 1.7 million acres of grassland and shrubland were converted to cropland each year (Lark et al. 2015). With hundreds of ranchers on federal waiting lists to receive easements to protect their grasslands from conversion in the Prairie Pothole region alone (U.S. Fish & Wildlife Service 2012), additional investments in easements would protect these important carbon stores, in addition to the ecosystem services that they provide for water quality (Johnson et al. 2016), pollinator habitat (Hopwood 2008), and waterfowl nesting (Reynolds et al. 2006), among others.

Cover Crops—Cover crops are grown in the fallow season between main crops; they can roughly double the number of days each year that a living cover is pulling carbon from the atmosphere and sequestering it in the landscape. Cover crops add about half a tonne of CO_2 per acre per year to the soils (Poeplau and Don 2015). We estimate that cover crops can be added to the 217 million acres of cropland used for the five primary crops (corn, soy, wheat, rice, and cotton) that are not already using cover crops (Conservation Technology Information Center et al. 2017). It is possible to use cover crops on cropland planted to crops other than these five primary crops, but agronomic research demonstrating the successful use of cover crops is limited outside of these primary crops, so we conservatively limited the maximum area of cover crop use to these five crops. The benefit that cover crops provide varies from place to place. The amount of sequestration depends on interactions between the climate, soils, the cropping rotation of cash crops, and which cover crops are used. However, on average, researchers consistently find soil carbon sequestration of 0.3–0.6 tonnes of CO_2 per acre under cover crops (Tellatin and Myers 2018).

Biochar—Biochar is made by heating biomass while restricting the amount of available oxygen, which creates charcoal. This charcoal can be incorporated into agricultural soils, where it increases soil carbon, increases water holding capacity, and can boost crop yields (Aller et al. 2018). Unlike biomass that has not been turned into biochar, the majority of carbon in biochar does not decompose after being incorporated into the soil. We estimated the carbon sequestration benefit from turning 144 million tonnes of biomass into biochar, the amount of additional biomass from agricultural residue that could be sustainably harvested in 2025 (U.S. DOE 2016). We assumed that 79.6% of biochar carbon persists on a timescale of >100 years (Liang et al. 2008, Dharmakeerthi et al. 2015) and that there are no effects of biochar on emissions of nitrous oxide or methane (Song et al. 2016, Wang et al. 2016). While biochar is not yet in widespread use, the science is clear that it could effectively store carbon. Improved cost-effective biochar production equipment and techniques and additional in-field agronomic research quantifying the benefits of biochar application are needed in order to provide both the means and the motivation for farmers to start building soil carbon using biochar.

Alley Cropping—Alley cropping is one way to incorporate more trees in agriculture. Alley cropping is planting widely spaced rows of trees with an annual crop grown in the alleyways between the rows. Trees considered for alley cropping include black walnut, hazelnut, chestnut, and pecan, which can provide timber and/or nuts, or pine trees that can provide pine straw for landscaping (Garrett et al. 1991, 2015, Revord et al. 2019). These added revenues mean that alley cropping offers increased profitability in many cases (Garrett et al. 2015, Wolz and DeLucia 2019). We estimated a maximum potential of alley cropping on 10% of U.S. cropland, or 37 million acres (Udawatta, Ranjith P., Jose 2011). Alley cropping sequesters about 2.2 tonnes of CO_2 per acre per year (Fargione et al. 2018).

Cropland Nutrient Management—Nitrous oxide is a potent greenhouse gas that is about 300 times as powerful as CO_2. Of the nitrogen fertilizer added to farm fields, about 2.5% ends up being emitted to the atmosphere as nitrous oxide, either directly from the farm field or indirectly after nitrogen leaks from farm fields to streams and wetlands (Davidson 2009). We estimated the benefit of the implementation of best practices that can maintain yields, increase profitability, and decrease nitrous oxide emissions. We considered four improved management practices: (1) reduced whole-field application rate, (2) switching from anhydrous ammonia to urea, (3) improved timing of fertilizer application, and (4) variable application rate within field. Because these practices improve efficiency, they decrease the total amount of fertilizer production that is necessary, reducing the fossil fuel emissions necessary for its manufacture, which we also account for (Snyder et al. 2014). Based on these four practices, we found a maximum potential of 22% reduction in nitrogen use, which leads to a 29% emission reduction, including emissions from fertilizer production.

Improved Manure Management—Manure lagoons from dairy cows and hogs release methane, a potent greenhouse gas about 34 time more powerful than CO_2. For large farms, it can be economical to capture this methane to use for on-farm heating

or for electricity generation, although cost sharing for initial capital costs may be necessary (Klavon et al. 2013, Lauer et al. 2018). We estimated that there are 24 million tonnes of CO_2 per year of potential for emissions reductions from improved manure management on dairy farms with over 300 cows and hog farms with over 825 hogs. Our calculations are based on improved management practices described in Pape et al. (2016).

Windbreaks—Windbreaks help reduce soil loss from wind erosion and can increase crop yields by sheltering crops from damaging winds and creating favorable microclimates that increase yields (Brandle et al. 2004). We estimated that windbreaks could be planted on about 2 million acres, calculated assuming that 43 million acres of cropland that would benefit windbreaks and that windbreaks would be planted on ~5% of that cropland (Pape et al. 2016). We estimated that windbreaks provide 5.28 tonnes of CO_2 per acre per year of sequestration in tree biomass and soils (Kort and Turnock n.d., Sauer et al. 2007, Schoeneberger 2008, Wang et al. 2013, Chendev et al. 2014).

Grazing Optimization—Well-managed grazing lands store more carbon in their soils than grasslands that are either over-grazed or not grazed at all (McSherry and Ritchie 2013, Hewins et al. 2018). In general, more productive systems store more carbon, suggesting that practices that avoid degradation and promote plant growth will maximize grassland productivity, rancher profit, and carbon storage. A global study (Henderson et al. 2015) estimated that "grazing optimization" could be applied to 131 million acres in the United States with a modest soil carbon sequestration benefit of 1/14th of a tonne of CO_2 per year. Grazing optimization prescribes a decrease in stocking rates in areas that are over-grazed and an increase in stocking rates in areas that are under-grazed, but with the net result of increased forage offtake and livestock production. While there is increasing interest and enthusiasm around various rotational grazing practices that may achieve more significant soil carbon storage per acre in some instances (Teague et al. 2015), additional research is needed to be able to predict which practices will have a strong carbon storage benefit in particular climates and soil types (Briske et al. 2008, 2011, Hawkins 2017).

Grassland Restoration—Since 2007, over 13 million acres have been lost from the federal government's Conservation Reserve Program. Much of this former conservation set-aside land has been put back into row crops (Morefield et al. 2016). Restoring marginal cropland to grassland, e.g. through increasing the acres enrolled in the Conservation Reserve Program, sequesters about 1.8 tonnes of CO_2 per acre per year in soils and root biomass. Grassland restoration also helps support conservation goals for water quality (Johnson et al. 2016), pollinator habitat (Hopwood 2008), waterfowl nesting (Reynolds et al. 2006), and wildlife habitat.

Legumes in Pastures—Legumes help increase soil fertility by converting nitrogen in the atmosphere into a form that is available to plants; this increased availability of nitrogen helps both fertilize the soil and further store soil carbon. Seeding legumes in pastures increases both the amount and quality of forage, increasing productivity for beef and dairy cattle. A global study (Henderson et al. 2015) estimated that legume planting could be applied to 14 million acres of pastures in the United States with a soil carbon sequestration benefit equivalent to half a tonne of CO_2 per year (after accounting for the potential for legumes to increase nitrous oxide emissions). We do not recommend seeding legumes into native prairie rangeland, as this could negatively impact the diversity of native prairie plants. Rather, this practice should be implemented in planted pastures, which are already comprised primarily of introduced species.

Improved Rice Management—Flooded rice paddies emit methane, a potent greenhouse gas that is about 34 times more powerful than CO_2. There are roughly 3 million acres of rice in the United States. Practices including mid-season drainage, alternate wetting and drying, and residue removal can reduce these emissions by roughly 40%, with an average avoided emissions benefit equivalent to 1.4 tonnes of CO_2 per acre per year (Yan et al. 2009, Pittelkow et al. 2014, Sander et al. 2015, Peyron et al. 2016). We used an EPA analysis that projects the potential for improvement across U.S. rice fields, in comparison with current agricultural practices (US EPA et al. 2013).

Tidal Wetland Restoration—In the U.S., 27%, or roughly one million acres, of tidal wetlands (salt marshes) have limited tidal connection with the sea, causing their salinity to decline to the point where methane emissions increase (Kroeger et al. 2017). We estimated the potential for reconnecting these tidal wetlands to the ocean to increase salinity and reduce methane emissions. This opportunity avoids emissions of the equivalent of almost ten tonnes of CO_2 per acre per year. Reconnecting these wetlands can be accomplished by widening culverts or installing tide gates (http://www.edc.uri.edu/restoration/html/tech_sci/restsalt.htm). Restored salt

marshes act as fish nurseries, provide bird habitat (Barbier et al. 2011, Correll et al. 2017) and reduce flood risk and shoreline erosion. We note that our estimate omits drained tidal marshes due to lack of information about the extent to which they could be restored. Many drained tidal marshes are developed and thus are unlikely to be restored. However, drained tidal marshes that were cropped have the potential to recover large amounts of soil carbon (Anderson et al. 2016, Holmquist et al. 2018). Inclusion of these additional restoration opportunities would reveal even greater potential for tidal marsh restoration than quantified here.

Wetland Restoration—Wetlands store large amounts of carbon, because wet soils inhibit decomposition. When wetlands are drained, these large stores of carbon begin to decompose. Protecting existing wetlands and restoring drained wetlands helps store carbon and protects what carbon remains in these systems. Wetlands also emit methane, a potent greenhouse. After accounting for these methane emissions, there is still a net greenhouse gas benefit to wetland restoration, which we estimate at the equivalent of roughly 1.2 tonnes of CO_2 per acre per year. Our estimate of mitigation potential accounted for changes in soil carbon, biomass, and methane emissions, considering regional differences, the type of land use of the converted wetland, and whether or not the wetland was originally forested. We estimated that there are about 7 million acres of restorable wetlands, based on the difference between historic wetland extent [as determined by the extent of Histosols in soil maps (Soil Survey Staff 2016)] and current wetland extent.

Avoided Seagrass Loss—Seagrass traps and stores sediment in shallow ocean waters. Seagrass stores, on average, 211 tonnes of CO_2 per acre, and of this, an estimated 132 tonnes of CO_2 per acre are released to the atmosphere when seagrasses are lost (Pendleton et al. 2012). Seagrass habitat is being lost due to nutrient pollution and other human impacts (Orth et al. 2006). An estimated 1.5% of seagrass extent is lost every year (Waycott et al. 2009). Applying this to the estimated 3.6 million acres of remaining seagrass in the United States (CEC 2013, 2016), we estimate about 50,000 acres of seagrass loss per year. Such losses could be avoided by efforts to reduce nutrient pollution in seagrass habitat, as has successfully been achieved in Tampa Bay through waste water treatment plant upgrades, stormwater treatment, phosphate industry best management practices and fossil fuel power plant upgrades for nitrogen control (Morrison and Greening 2011, Cooper 2012, Sherwood 2017).

Seagrass Restoration—We estimate that there are 4.5 million acres of lost seagrass habitat that could be restored (Waycott et al. 2009). Restoration techniques include natural recolonization, seeding, and transplanting in locations where pollution has been sufficiently reduced to enable restoration (van Katwijk et al. 2016). Restored seagrass sequesters an estimated 1.3 tonnes of CO_2 per acre per year (Thorhaug et al. 2017).

CONCLUSION

I'm optimistic that we can implement Natural Climate Solutions through targeted investments and policies at a scale that will meaningfully contribute to fighting climate change. These approaches are gaining traction because there are so many good reasons to implement Natural Climate Solutions, even beyond climate. From reducing costs for farmers to improving air quality for people to protecting coastal communities from flooding, the benefits are numerous. Natural Climate Solutions are low cost and are available now. For all these reasons, the time is right to invest significantly in Natural Climate Solutions.

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Ms. CASTOR. Thank you. Vice Chairman Myers, you are recognized for 5 minutes.

STATEMENT OF VICE CHAIRMAN FRANKIE MYERS

Mr. MYERS. Thank you. [Speaking native language.] Chairwoman Castor, Ranking Member Graves, and committee members. Thank you for the invitation to testify today about the role of forests in cutting pollution and building resiliency. Per our traditional protocol and policy, I am going to open with a prayer before I give my statement.

[Speaking native lanaguage.]

FRANKIE MYERS. I am the vice chairman of the Yurok Tribe, the largest federally recognized tribe in California, with around 6,500 members. Our aboriginal territory spanned about 1.5 million acres of oceans, rivers, redwood forests, and upland prairies. Our reservation now includes one mile on either side of the Klamath River from the mouth of the river up 45 miles.

I want to start off by dispelling a myth that nature is wild. Nature, in Yurok belief, is only natural when humans are a part of it. It is a tenet of Yurok belief that you have to be a part of the world around you to truly have a natural forest and ecosystem.

Our current force management policies recognize that by using our time-tested indigenous knowledge, we can develop a healthy, functioning forest ecosystem that will provide long-term benefits, certainty, and resiliency, to the impact of climate change.

Resource management planning must focus on long-term management, goals and objectives, guided by a clear vision of the future of our forests, rather than focus on short-term benefits of extractive management. Our forests' ecosystem function and integrity need to be held to equal value with the economic benefits of forests. This approach will bring back balance to the forest, a balance that was lost due to intensive extractive force practices.

Bringing back balance starts with returning land to the traditional stewards. For us, thousands and thousands of acres were lost in the mid and late 1800s through federal Indian land policy. The original Yurok reservation was cut down to a mere 4,000 acres.

For over a century, Yurok ancestral force lands were used by non-Indians as commercial timberlands, turning our precious, old-growth coast of redwood forest, into a network of dirt roads, timber-slashed piles and clear-cut hills. These monoculture forestry practices decimated wildlife habitat, suppressed the native ecology, and destroyed the abundant natural resources that were created over centuries of traditional land management practices.

To implement the tribe's force management policies as well as heal from historical losses, the Yurok Tribe has been actively working to recover its homeland with a goal of restoring balance. In 2018, after two decades of working with the Yurok, the Yurok Tribe reacquired nearly 60,000 acres of our traditional forest lands adjacent to the reservation.

Through the reacquisition of forest lands, the tribe is engaging in forestry practices, gathered by traditional knowledge, backed by Western science, with the goal of restoring the forest lands to a dynamic ecosystem.

One example is the tribe's carbon project. The Yurok was the first tribe to participate in Southern California Air Resource Board-issued carbon offsets, credits in the State's cap and trade program. By 2020 we will manage multiple improved forest management projects in the cap and trade program, totalling over 47,500 acres on and adjacent to the Yurok reservation.

The program provides for a market mechanism for reducing carbon dioxide emissions from California's largest CO_2 emitters. The program works by limiting or capping the amount of emissions large corporations and industries emit. The emission limit is then reduced over time so that total emissions will decrease to meet State targets.

Carbon sequestration, like Yuroks', supply the carbon offits for the regulated entities to meet the reduction limits. On the carbon offset seller side, carbon projects are developed on forest lands that may otherwise be used for extractive purposes. This effort, coupled with the Yurok Lands Act Bill, pending in the House now, which would also add to the Yurok Reservation and our stewardship, would include carbon projects and allow the tribe to manage our natural resources in a way that builds and improves climate change resiliency and cuts pollution.

We urge the Congress to support the Lands Act and encourage this committee to support values, policies, and programs that hold equal forest ecosystem functions and integrity with the economic benefits.

Thank you.

[The statement of Mr. Myers follows:]

Testimony of Vice Chairman Frankie Myers
Vice Chairman, Yurok Tribe

Before the U.S. House of Representatives, Select Committee on the Climate Crisis
"Solving the Climate Crisis: Natural Solutions to Cutting Pollution and Building Climate Resilience"

October 22, 2019

Good afternoon, Chairwoman Castor, Ranking Member Graves, and Subcommittee Members. Thank you for the invitation to testify today about the role of forests in cutting pollution and building resilience. My name is Frankie Myers; I am the Vice Chairman of the Yurok Tribe. I am a Yurok traditional religious practitioner, fisherman, hunter, and have lived on the Yurok Reservation for my entire life. I have worked for the Yurok Tribe for most of my career, and have served as the Vice Chairman for over a year.

The Yurok Tribe recognizes the direct threat and impacts of climate change to the Yurok Tribe, citizens of the State of California, United States, and global communities. Since time immemorial, the Yurok Tribe has acted purposefully to serve as responsible stewards of our land, culture, air, and water resources, and we will continue to expand and advance our capacity to restore and manage these resources for Yurok people. Our long-term strategic vision for the management of Yurok natural resources is based on our traditions and culture, but guided by modern, science-based adaptive management.

The Tribe has been opportunistic in finding mechanisms to support the restoration of our forests. As one of the first participants in the California cap-and-trade program, we have witnessed firsthand the program's environmental, cultural, legal and economic benefits. The California cap-and-trade program has allowed the Yurok Tribe to not only reacquire misused forestlands within our ancestral territory, but has allowed us to actively manage those lands to restore them to produce many climate benefits. This restoration effort will allow the forests to function as intended, sequestering carbon, releasing oxygen, and providing invaluable ecosystem services. The effort will also allow our Tribal members to use the land as our ancestors did and support recovery of the wildlife and aquatic species that are now imperiled. The restoration of our ecosystem can, and should, be a top priority to address and combat climate change, reduce pollution and build resiliency.

I. HISTORY OF YUROK PEOPLE

The Yurok people have occupied the pacific coast of Northern California and inland on the Klamath River since time immemorial. Our aboriginal territory included over 1.5 million acres of ocean, lagoons, redwood forest, the lower 45 miles of the Klamath River, and our sacred high country in what is now known as Northern California. Our aboriginal territory is one of the most wild, biodiverse, and ecologically unique places on the planet that includes the tallest trees in the world, some of the most ancient and largest fish on the planet, and the only fresh water lagoons on earth. From the beginning, we have followed all the laws of the Creator, which became the whole fabric of our tribal sovereignty.

In times past and present, the Yurok people have blessed the deep river, the tall redwood trees, the rocks, the mounds, and the trails. We pray for the health of all animals, and prudently harvest and manage the great salmon runs and herds of deer and elk. We never waste and use every bit of the animal or plant. Traditionally, our stewardship of the prairies and forests consists of controlled burns that improve wildlife habitat and enhance the health and growth of tan oak acorns, nuts and berries, grasses and bushes. We use all of these for food and materials for baskets, fabrics, and utensils. These practices led us to become early implementers of California's cap-and-trade program.

For millennia our religion and sovereignty have been pervasive throughout all our traditional villages. Our village way of life requires use of the sweathouse, extensive spiritual training and sacrifice, and firm adherence to tribal law. The Klamath River was and remains our highway, and from the beginning we have utilized the river and the ocean in dugout canoes carved from redwood trees. Our people come together from many villages to perform ceremonial construction of our fish dams, and to participate in our annual ceremonies. Our Yurok Country stayed in balance,

kept that way by our good stewardship, hard-work, wise laws, and constant prayers to the Creator.

Our social and ecological balance, thousands and thousands of years old, was shattered by contact with non-Indians in the mid-1800s. In 1851, California's first Governor promised "a war of extermination will continue to be waged between the two races until the Indian race becomes extinct." In finally apologizing on behalf of California, Governor Newsom, in 2019, called this what it was—"genocide." For us, it is not history. We lost more than seventy-five percent of our people through unprovoked massacres and diseases. After goldminers swarmed over our land, we signed a "Treaty of Peace and Friendship" with representatives of the President of the United States in 1851, but then the United States Senate failed to ratify the treaty. Then in 1855, the United States ordered us to be confined to the Yurok Reservation (then called the "Klamath River Reservation"), created by Executive Order. In 1864 and 1891, our reservation was merged with the Hoopa Valley Reservation. But even this small remnant of our ancestral land did not last long.

In the late 1890s individual Indians received allotments from the tribal lands on the Yurok Reservation and almost all of the remainder of the Reservation was declared "surplus" and opened for homesteading by non-Indians. The forests were logged excessively and wildlife was depleted. Even the great salmon runs went into deep decline. In the mid-1930s, the State of California attempted to illegally terminate traditional fishing by Yurok people. Our rights were judicially reaffirmed in the 1970s and 1980s after decades of legal and physical battles. Then, in 1988 Congress passed the Hoopa-Yurok Settlement Act to separate the Yurok Reservation from the Hoopa Reservation and distribute tribal assists. The Yurok Reservation remained under Yurok control with only slightly over 5,000 acres of trust land while the Hoopa Reservation remained under Hoopa control with over 90,000 acres of trust land.

In a matter of 130 years, the Yurok people lost over 1.49 million acres of land. In the Hoopa-Yurok Settlement Act, Congress recognized that the Act was not favorable to the Yurok people. It included in the Act two provisions to address the inequities. The first, an authorization for the Tribe to acquire more land adjacent to the Yurok Reservation, and the second, an authorization for appropriations to purchase more land. Congress also expressed its intent to continue to work with the Tribe to rebuild its land base through appropriating federal funding to purchase land and supporting future land acquisition.

Against all odds, we have resisted, survived and maintained our culture and our people: in part, because we were never relocated, and in part because we believe in our cultural and religious traditions. Today, we are the largest California tribe with over 6,400 tribal members. Indeed, many tribal members still live a traditional subsistence based way of life. Every year we hold tribal ceremonies, dancing for the health of babies and to balance the world. Many of us still live in our traditional villages along the Klamath River where our ancestors lived, and subside based on a fishing, hunting, and gathering life way.

Today, we are lawyers, doctors, soldiers, judges, artists, amongst other occupations and we proudly continue to live our traditional ways. But it is not easy. The annual income on the reservation is $11,000 and many of our members live well below the poverty line. They attempt to make ends meet through supplementing food sources with subsistence activities, hunting of deer and elk and fishing of salmon, sturgeon, eels, and other fish. But the resources of the reservation continue to be diminished by off reservation development. Specifically, the Klamath River salmon runs over the last four years have been the lowest on record. The salmon have been killed by various fish diseases caused by poor water quality, high water temperatures, and low flows all of which are caused by dams and agriculture. We have been forced to close our fishery and we have declared a fishing disaster every year for the last three years. Animals on the land are in decline because of lack of habitat due to logging, spraying of pesticides on reservation by logging companies, and massive illegal marijuana grows.

While much has been lost, the spirit of the Creator and our inherent tribal sovereignty still thrive in the hearts and minds of our people as well as in the strong currents, deep canyons, thick forests, and high mountains of our ancestral lands. The Yurok Tribe has emerged, strong and proud from the tragedies and wrongs of the years since the arrival of non-Indians into our land. Our sacred and vibrant traditions have survived and are now growing grander and richer each year.

Our future lies in sustainable economic development based on our rich natural resources, cultural traditions, and preservation of our way of life. There is little economic opportunity in our area, and it is up to us to use our limited resources to advance our people.

II. FORESTS AS NATURE BASED SOLUTION TO CLIMATE CHANGE

In 2011, the Yurok Tribe became one of the first participants in the California Cap-and-Trade Program (Cap-and-Trade Program) by participating in the development of the California Assembly Bill 32: Global Warming Solutions Act and operating one of the first carbon sequestration projects under the Act. By 2020 we will manage multiple Improved Forest Management projects, totaling over 47,500 acres on and adjacent to the Yurok Reservation that are registered in the California Air Resources Board ("CARB") as part of the Cap-and-Trade Program which we refer to as the "carbon project."

The carbon project is part of a two-decade land acquisition effort whereby the Tribe reacquired nearly 60,000 acres of forestlands within its ancestral territory that was completed in 2018.[1] These lands—along with tens of thousands of other Yurok ancestral forestlands—were lost in the mid and late 1800s through federal Indian land reservation and allotment policies, allowing millions of acres of tribal lands across the nation to pass to non-Indian ownership. After allotment, the original 25,000-acre Yurok Reservation (including the lower 22 miles, and approximately half the acreage, of the present-day Yurok Reservation), representing only a fraction of the Tribe's ancestral territory, was cut down to less than 4,000 acres of Tribal lands. For over a century, Yurok ancestral forestlands were used by non-Indians as commercial timberlands, turning a dynamic old-growth coastal redwood forest ecosystem into a network of dirt roads, timber slash piles, and clear-cut hill slopes, driven by monoculture forestry practices that decimated wildlife habitat and suppressed the native ecology. But now, through the reacquisition of forestlands, the Tribe is engaging in forestry practices guided by traditional knowledge and contemporary scientific knowledge with the goal of restoring the forestlands to a dynamic ecosystem the forest once knew and allowing Yurok Tribal members to interact with the landscape as they have done since time immemorial.

To facilitate the land acquisition funding, the Tribe developed carbon projects on certain parcels of the forestlands. In doing so, Yurok was the first tribe to participate in selling California Air Resource Board ("ARB") ARB issued carbon offset credits in the State's cap-and-trade program. The program provides a market mechanism for reducing carbon dioxide emissions from California's largest polluters who are regulated by the State. The program works by limiting, or capping, the amount of emissions large polluters can emit. That emission limit is then reduced over time so total emissions will decrease to meet state targets. The regulated entities can buy carbon offsets to help meet their emission limits along the way, but still ensuring that pollution volumes decrease. Carbon sequestration projects, like Yuroks, supply the carbon offsets that the regulated entities may buy to meet their limits. On the carbon offset seller side, carbon projects are developed on forestlands that may otherwise be used for other extractive purposes, primarily industrial timber. When a party, like Yurok, decides to create a carbon project, it agrees to maintain the forest's ability to sequester carbon for 100 years. During that time, the forest cannot be managed to lower the amount of carbon it sequesters at the time of project outset. Thus, forest carbon projects work by requiring forestlands to remain intact as forests for 100 years, maintaining and growing the amount of carbon those forests sequester over that time.

The largest project, on the "Phase 1" property, was developed in 2011 and covers over 22,000 acres of forestland. The smaller project—Cook Coppala Gerber Gleason—is approximately 9,000 acres and was developed in 2012. The Tribe has benefited greatly from its participation in the California carbon market. The revenues realized from its carbon sales have been used to pay back loans for the reacquired lands and, critically, are used for on-the-ground management and operations expenses.

Both carbon projects are defined as improved forestry management forest projects, where "The Forest Owner must adhere to a renewable long-term management plan that demonstrates harvest levels which can be permanently sustained over time . . . ." By including a carbon project on Yurok-managed forestlands, the Tribe undertook a management initiative that included timber harvesting but cabined by the need to sustain and grow the carbon sequestering potential of the forests. For the Tribe, these seemingly contrasting goals actually supported each other. Because the forests had been historically harvested so heavily and were in unnatural and even ecologically dangerous condition, they demanded active management to restore them. Such work required a level of timber harvest to remove dense timber stands

[1] For a thorough discussion of the Tribe's carbon project and land acquisitions, *see attached* Beth Rose Middleton & Kaitlin Reed, *Returning the Yurok Forest to the Yurok Tribe: California's First Tribal Carbon Credit Project*, 39 STAN. ENVTL. L. REV. (forthcoming Jan. 2020).

that would be small, regular, but sustainable. In turn, the remaining forest could grow stronger and faster, sequester more carbon, and provide for better wildlife habitat.

a. Traditional/Historical Resource Management of Yurok Forests

The Yurok Tribe possesses a profound connection to the land, air, water, and animal resources of the natural world. These resources have provided for the cultural, spiritual, and physical health and well-being of the Yurok people since time immemorial. Historically, Yurok people were care-takers of the natural world, respecting and managing the natural resources that they relied upon for survival. Tribal members were conscious of the physical and biological cycles of the natural world, and lived in ways that respected those cycles. Disregard of theses cycles could easily cause imbalance and disruption of the natural balances of the ecosystem, and seriously threaten the health and survival of families, villages, and the Tribe as a whole. To avoid disruptions and threats to Yurok survival, strong cultural traditions guided the rhythms of life, and the utilization and management of critical natural resources. Natural resources were managed comprehensively for eco-system wide health. The harvesting and gathering of resources were closely managed. Seasonal gathering times and places were in rhythm with these natural cycles, and meant to harvest only what was needed to meet the needs of the people. Hunting places, and fishing places were respected, and resources were shared among the people. This ensured balance with the natural world, provided consistency and assurances, and resiliency in times of hardship and strife.

A strong, vigorous, and healthy natural ecosystem remains just as important to the Yurok Tribe now, as in historical times. The cultural, spiritual, and physical health and well-being of the Yurok People continues to be bound and connected to the well-being of the natural world. We envision a renewed and restored natural ecosystem, that when managed carefully, with respect and balance, will provide for the needs of Yurok People now and for generations to come. Tribal members will have the ability to actively manage their lands, to gather, hunt, practice Yurok ceremonies, and pray for spiritual and world renewal.

Natural resources are also considered the cultural resources of the Yurok Tribe. The cultural resources are broad, and encompass the landscape, and all the natural resources within it. Significant cultural resources include, but are not limited to; elk, deer, marten, fisher, otter, pileated woodpecker, acorn woodpecker, stellar jay, grouse, hazel, bear grass, acorns, huckleberry, mushrooms, and a variety of medicinal plants. Coyote, frog, and salamander are important animals also, and are embedded in many Yurok stories of the spiritual world. All, are currently found in Blue Creek and surrounding tribal lands. We desire, and strive to protect, restore, and manage these resources to meet the cultural and economic needs of tribal members now and for the generations of Yurok People to come through conservation-based management, and sustainable forest management.

The Yurok Tribe wishes to share the benefits of this restored ecosystem with other stakeholders, and apply the knowledge and lessons learned from our experience with other tribes and state and federal land managers, and apply it to other watersheds in the Klamath-Trinity River basin.

b. Contemporary Yurok Forest Management

The Yurok Tribe recognizes that developing healthy, functioning forest ecosystems, will provide long-term benefits, certainty, and resiliency to the impacts of climate change. Forest resources can be enhanced with the careful and thoughtful, science-based application of various methods of thinning, logging, and other careful application of culturally prescribed fire. It may take 50 or more years to return the whole landscape to a state of equilibrium where the forest and its' resources are healthy, resilient, and abundant. Resource management planning must account for this timeframe, and focus on long-term management goals and objectives, guided by a clear vision of the future state of the forest, rather than focusing on the short-term benefits of extractive management. The Yurok Tribe's vision is long-term, and includes application of sustainable forest practices, uneven-aged forest management, acceleration to mature and old growth forest types, and careful implementation of forest prescriptions that support ecosystem function, and integrity. The Yurok Tribe believes that forest ecosystem function and integrity should hold equal value, and be balanced with the economic benefits the forest can provide. This vision, recognizes the inherent value of the forest, for the various resources and economic support it provides, but also for the cultural, spiritual, and ecological benefits of a healthy forest. Implementation of this vision would not preclude other activities such as logging and other forest management techniques from occurring; rather it needs to include wisely managed selective-timber harvest, pre-commercial thinning

of overstocked stands, and other modern vegetation management techniques. The Tribe believes this long-term, balanced approach will respect and honor traditional values and methods, but also be a solution to improve forest health, increase carbon sequestration, improve water quality, protect fish and wildlife habitats, and increase resistance and resiliency to uncontrolled wildfires.

c. Importance of Culturally Prescribed Fire and Fuels Management

Healthy forests, provide ecological stability, and resiliency to the impacts climate change, including; accelerated loss of fish and wildlife habitats, degraded air and water quality, and increased intensity and severity of uncontrolled wildfires. Wildland fires within our forests can be devastating to both the forest ecosystem, result in massive economic costs, and loss of resources, property, and human lives. Healthy, functioning forest ecosystems, with diverse species composition and age-structure can increase resiliency to the impacts of wildland fire, and help protect sensitive fish and wildlife species, and the communities which rely upon them. Although wildfires can potentially be harmful if uncontrolled, and initiated in dense, over-stocked, unhealthy forest types; the safe and responsible application of prescribed fire had been used as a traditional land management technique, and has proven to promote and ensure the healthy forest ecosystems that have supported Yurok People since time immemorial.

Unfortunately, decades of fire suppression, and industrialized commercial logging activities in the Klamath-Trinity River basin has created an unhealthy forest condition. This unhealthy condition was created by short-term extractive management, and severely degraded fish and wildlife habitats, water quantity and quality, and increased the threat of catastrophic wildfire. Forests that have experienced decades of fire suppression and commercial timber management have resulted in very dense, even-aged, overstocked forest stands, and excessive fuel loading conditions. These conditions, and the risk of catastrophic wildfire have been compounded by climate change. Increased regional annual air temperatures, changes in the natural hydrologic cycle, and changes in seasonal weather patterns exacerbates the risk of catastrophic wildfire across the landscape, and the potential impacts to forest resources and the communities that rely upon them.

The Yurok Tribe promotes the application of modern, science-based land and natural resource management techniques across a landscape scale. However, there is also a recognition of the need to adapt modern management, and integrate with traditional Yurok ecological knowledge and values. Culturally prescribed fire has been used for centuries by the Yurok Tribe to reduce fuel loading, maintain prairies and grasslands from forest encroachment, improve habitat and forage for wildlife, and promote growth of culturally important basket materials, foods, and medicines for Yurok People. In recent years, with the support of both tribal and non-tribal communities, the Yurok Tribe has coordinated with state and federal agencies to responsibly, and carefully restore the application of culturally prescribed fire as a management tool on tribal lands. Regular application of low-intensity, culturally prescribed fire can promote forest health through reduction of fuels, increased nitrogen cycling, and increase and accelerate forest stand diversity and age-structure. The Yurok Tribe believes that through inter-agency partnerships, integrated resource planning, and application of culturally prescribed fire can be an important tool to promote healthy forests, protect against the impacts of catastrophic wildland fire, and increase resiliency to the impacts of impending climate change.

III. DECLARING PERSONHOOD RIGHTS TO NATURE FOR CLIMATE RESILIENCY

The Yurok Tribe has a long history of protecting the Klamath River including through the establishment of the Yurok Constitution, Tribal Law, and many lawsuits, administrative proceedings, petitions, and grassroots activism. On May 9, 2019, the Yurok Tribal Council adopted Resolution 19–40 granting the rights of Personhood to the Klamath River and established the Rights of the Klamath River to exist, flourish, and naturally evolve; to have a clean and healthy environment free from pollutants; to have a stable climate free from human-caused climate change impacts; and to be free from contamination by genetically engineered organisms. The Klamath is the first river in Northern America to have personhood rights declared.

This change in Yurok law was based on the Yurok Tribal Council's recognition that in the face of unpredictable and drastic impacts from the changing climate, Yurok courts would need a legal structure that would allow for holistic review of the harms impacting the Klamath River and a path to remedy those harms. Any remedies awarded by the courts will go directly back to the Klamath River in the form of clean up or restoration projects to address the harms litigated in court, thus providing a legal avenue to keep those who would harm the River accountable.

The Rights of the Klamath River also incorporates and recognizes the Yurok relationship and experience with the River and its ecosystem through traditional ecological knowledge. The law encourages the Yurok people to continue living and practicing their traditional lifeways to harvest plants, salmon and other fish, animals, and other life-giving foods and medicines for both subsistence and commercial uses. The law also establishes the rights of the Yurok people to protect and represent the River in Yurok courts if they witness harms impacting the River. Through this legal mechanism, the Yurok Tribal Council wished to encourage the courts to hear and adopt traditional ecological knowledge to ensure the reciprocal relationship to care and protect each other between the Yurok people and the Klamath River can be fully adopted in judicial proceedings.

We see this change in the law as a climate change adaptive measure to increase climate resiliency because it will allow the courts to address a wider range of unpredictable harms impacting the Klamath River and ensure Yurok traditional ecological knowledge can be incorporated in judicial proceedings.

IV. OCEAN ECOSYSTEM INSTABILITY

In addition to salmon, the Yurok Tribe has long been dependent on the marine resources in its aboriginal territory. Traditional Yurok villages existed all along the coast from Damnation Creek to south of present-day Trinidad, California (Tsurai Village), a stretch of coast spanning over 80 miles. Nearshore marine resources were carefully managed through traditional knowledge and traditional cultural practices for thousands of years. In addition, the primary resource that Yurok rely on, the great salmon, steelhead, lamprey, sturgeon and eulachon runs all depend on the marine environment and its rich food resources for part of their lives.

Although the Yurok intend to continue this tradition and practice of stewardship of marine resources, climate change now presents an existential threat to these resources. One of the predicted effects of climate change is ocean ecosystem instability, which will have profound effects to the Yurok people. Several primary factors related to climate change are responsible for this instability:

(1) ocean acidification interferes with the ability for plankton and other animals to make calcium carbonate shells;

(2) currents and winds will change in unpredictable ways that could have significant consequences to the physical environment, and;

(3) warmer temperatures will bring about a shift in species composition including food species and predator species.

Ocean acidification is caused directly by increased CO_2 concentrations which in turn dissolve into the water and then create carbonic acid. Acidic conditions interfere with the ability for certain marine organisms such as mussels, and certain species of phytoplankton and zooplankton to create calcium carbonate shells. Because these species form the backbone of the marine ecosystem, acidification presents a threat to the very foundations of the food chain. Although the greatest effects are not expected for several decades, once acidification begins to interfere with these animals, the effects to the food chain will be devastating and impossible to reverse quickly.

Changing winds, currents and ocean conditions will also affect marine ecosystems. The nearshore ocean off the west coast of the United States is dominated by upwelling processes, which are primarily wind-driven near Yurok ancestral territory. Cold nutrient-rich water rises to the surface as nutrient depleted water moves offshore. This upwelling drives one of the largest, most productive marine areas in the world. Species from salmon, to killer whales and ultimately humans all depend on this rich and productive system. In 2014 through 2018, a "blob" of warm water that stretched from Alaska to northern California stopped the upwelling processes and decimated the food chain. In combination with river practices and fish diseases, this nearly wiped out the salmon runs. This condition returned in 2019, and is now occurring with alarming frequency. The 2019 salmon runs were a small fraction of its predicted size and it appears that a non-functioning marine ecosystem was to blame. Although it can be difficult to pin individual events such as this directly to climate change, given the extremely long memory of the Yurok people and the fact that this has not happened before, it is a reasonable hypothesis that these events are in fact linked to climate change.

The ceasing of upwelling and shift to warmer water temperatures have other deleterious effects. In addition to stopping upwelling processes, warmer water temperatures bring in new species that can either have a competitive advantage, or directly prey upon species important to the Tribe. For example, this year, when ocean temperatures reached about 8 °F above normal, albacore tuna were found much closer to shore in areas where salmon are usually found in colder waters. We believe these

types of changes are contributing to the loss of salmon on the west coast, although management of river flows, the presence of dams and other factors in the watersheds also play a significant role.

V. RECOMMENDATIONS FOR WORKING WITH TRIBES TO COMBAT CLIMATE CHANGE

Concurrently with reacquiring our traditional land base, the Tribe has been working on federal legislation to expand the boundaries of the reservation and empower the Tribe to respond to climate change. The Yurok Lands Act of 2019, H.R. 1312, was introduced into the U.S. House of Representatives earlier this year and a hearing on the bill was held in September in the Natural Resource Subcommittee on Indigenous Affairs. The paradigm-shifting piece of legislation seeks to strengthen the Yurok Tribe's sovereignty and capacity to self-govern. It expands the Yurok Reservation to include the land the Tribe recently reacquired, including the carbon projects lands, which is a critical step to ensure the project's success and long term viability. The bill also supports federal-tribal land management partnerships to ensure that tribal human, financial, and technical resources as well as ecological knowledge are incorporated into federal land management decisions affecting the Yurok Reservation. The bill empowers the Tribe to respond to climate change and we urge this Congress to pass it.

Further, the Yurok Tribe believes that partnerships between tribal, federal, state, international and private interests are vital to develop innovative solutions to address the complex problem of anthropogenic climate change, and critical to mitigating impacts and increasing the resiliency of natural and socio-economic systems. This Congress should support partnerships between tribes and other entities to facilitate climate adaptation and mitigation.

To that end, we offer the following specific recommendations:

- Congress should ratify and fully bind the United State of America to the United Nations Declaration of the Rights of Indigenous People ("UNDRIP"). Ratification of UNDRIP will ensure the United States respects the rights of indigenous peoples and their nations and territories, which in turn will protect the lands, resources, and cultural resources within the United States.
- Congress should also to enact legislation that would require all federal, state, local, and territorial governmental agencies to:

1. Conduct meaningful government-to-government consultation and obtain free, prior, and informed consent for all decisions that affect indigenous peoples and their traditional and ancestral territories;
2. Honor all treaties and agreements with indigenous peoples;
3. Protect and enforce the sovereignty and land rights of indigenous peoples;
4. Recognize and incorporate sustainable development principles in reducing greenhouse gas emissions and adapting to climate change, in order to simultaneously promote economic development, social well-being, national security, and environmental protection. Some of these principles include, but are not limited to:

a. Returning ancestral lands and waters to indigenous peoples to protect and manage;

b. Provide funding and political support for the development of green jobs and renewable energy infrastructure in lower socio-economic communities, communities of color, and in Indian Country;

c. Provide non-competitive funding to support culturally appropriate climate change resilience measures; and

d. Remove dams and restore water ways to their natural conditions.

5. Reduce U.S. greenhouse gas emissions to net zero or below as soon as possible, consistent with the latest peer-reviewed science; and
6. Work with other nation states and Native nations to reduce global greenhouse gas emissions to net zero or below and to hold the increase in the global average temperature to the lowest possible increase above pre-industrial levels.

Budget and Finance:

- Ensure consistent multi-year funding for Tribes through the BIA Tribal Resilience Grants and other funding programs including the Climate Science and Adaptation Centers, and the Landscape Conservation Collaborative Program.
- Increase funding for BIA programs which promote and support culturally prescribed burning and fuels reduction on tribal lands to improve forest health and increase wildland fire resiliency.
- Direct federal and state appropriations and create and streamline federal grant processes/programs to provide full support for tribal climate programs.
- Support federal and state financing for tribal priorities related to displacement, relocation and emergency services, and renewable energy production.

- Develop administrative rules that provide for tribal co-management of resources and land and provide funding to support co-management projects and programs.
- Fund tribes to conduct necessary marine studies for the marine portion of the life cycle of the fish.
- Fund tribes to study and manage its nearshore and intertidal marine resources.
- Address the need for stronger relationships between tribes and funders to increase understanding and effectiveness of funding.
- Address the impacts on funding resources that are caused by changing federal authorities.
- Tribes need site specific funding in terms of using Traditional Knowledge, integrating climate change and STEM education, accessing site-specific data, building tribal capacity, and implementation of projects.
- Encourage the Congressional Research Service to study available climate change related grants that tribes are currently excluded from and recommend how to open up funding mechanisms for Tribal governments to study, plan for and address climate change and ecosystem resiliency.

Carbon Policy/Greenhouse Gas Emission Reduction:

- Develop and pass equitable legislation related to cap and trade and or carbon tax/fee that specifically includes tribes, provides a set aside of revenues for tribes, increases tribal capacity, and provides tribal investments in carbon sequestration, carbon reduction actions, renewable energy, and climate adaptation and mitigation funding.
- Uphold the Paris Climate Agreement goals and coordinate implementing those strategies with tribes, state, cities, counties and organizations working to control Green House Gas emissions.
- Classify carbon revenue as trust revenue (through carbon offset projects developed by tribes)
- Create forest management plans that include carbon sequestration and consider ecosystem services.
- Federal Transit Administration guidelines should reflect Green House Gas emissions; Tribes need green infrastructure to solve transit issues.
- Federal mandates for green building to reflect Climate Change priorities should be integrated within Tribal housing programs.

Renewables/Energy Sovereignty:

- Promote tribal energy sovereignty that reflects climate change priorities including funding to develop tribal solar, wind, geothermal, energy efficiency and other green technologies.
- Congress should develop policies and incentives for tribes to develop renewable energy generation on tribal infrastructure and tribal trust lands. Congress should not support nuclear energy because of the harms uranium mining and the disposal of nuclear waste causes to indigenous communities and their environments.
- Decentralize renewable energy and provide incentives. Recognize the connections between housing and energy production.
- The Federal government should serve as a mediator between tribes and financial institutions to finance green building, renewable energy, etc.

Traditional Knowledge:

- Co-develop perspectives, research, and projects using Traditional Knowledge ("TK") to better understand and interact with unique cultural landscapes.
- Create scientific research questions that would lead to compatible management strategies, values, and goals between tribes and agencies.
- Ensure for the protection of cultural tribal knowledge. Disseminate information data sharing agreements early on in planning process and understand Freedom Of Information Act (FOIA) and how it can be problematic for protecting sensitive information.
- Create policy requiring the Free, Prior, and Informed Consent of Tribes when working with TK.
- Tribal Government and tribal perspectives need to be understood by agency staff and other partners when using TK.

Youth Engagement/Education:

- Fund and invest in multi-cultural and interdisciplinary science to raise awareness among tribal citizens and youth.

• Integrate climate change education into tribal communities through K–12 curriculum and community education programs.
• Bureau of Indian Affairs should re-invest in funding in youth programs, including internships to provide tribal youth and early career tribal citizens with the training and experience needed to address climate change.
• Assist Tribes to work collectively on youth and climate change education and STEM at the state, regional, national, and international levels.

Adaptation:

• Agency partnerships with tribes should be based on climate bioregions, and inform various partnerships networks that strengthen cross-boundary management. Continued support for Landscape Conservation Cooperatives is one example of this.
• Federal agencies need to provide more technical assistance in developing data sharing agreements and to make site-specific data more accessible to tribes.
• Work with BIA programs and other agencies to support tribal priorities: Food sovereignty, entrepreneurship, economic sovereignty, and energy efficiency.
• Tribal and natural resource agencies should promote diverse stand management structures and vegetation in their management and administrative practices to meet the need for creating resilient forest conditions, including restoration practices.
• Tribal adaptation plans should be looked at as models for non-tribal jurisdictions doing adaptation planning in regions covered or adjacent to Tribal plans.

Thank you for the opportunity to testify. We look forward to working with the Select Committee to address climate change.

Ms. CASTOR. Thank you very much. Dr. Howard, you are recognized for 5 minutes.

STATEMENT OF DR. JENNIFER HOWARD

Dr. HOWARD. Thank you, Chairwoman Castor, Ranking Member Graves, and members of the committee for inviting me today. It is a pleasure testifying today with Andy Karsner——

Ms. CASTOR. I am not sure if your microphone is on, or move it closer to you.

Dr. HOWARD. Is that better? I think they said this one was low. Can I borrow Andy's? Do I get my time to start over?

Okay. All right. Take 2. Thank you, Chairwoman Castor, Ranking Member Graves, and members of the committee for inviting me today. It is a pleasure testifying today with Andy Karsner, who sits on Conservation International's board of directors, and with Vice Chairman Myers. Our organization is working closely with the Yurok Tribe on the California tropical forest standard, and my colleague from TNC. TNC is a key partner with Conservation International on the subject of blue carbon.

I will start by saying that all people on earth depend directly or indirectly on the ocean. From the food we eat, our global economy and cultural values, the ocean touches every aspect of our lives and allows us to thrive on this planet. And now the oceans are demanding that we shift our thinking around climate change. It is not a problem restricted to the atmosphere. The atmosphere, land, and oceans all work together to regulate our planet, and changes to one will and have been impacting the others. Lest climate change is ocean change.

The IPCC, Ocean and Cryosphere Report, published last month, describes these changes in no uncertain terms. Today's ocean is warmer, rising, and more acidic. In my lifetime, extreme weather

events will be common, with extreme flooding events occurring annually. In my 2-year-old son's lifetime, most of the low-lying regions around the world may face adaptation limits as they succumb to sea-level rise.

That is scary, but it is not all bad news. Nature is a powerful ally, reducing emissions and protecting the coast through no-regret strategies where the planet and people both benefit.

No-regret strategy number one: conserve and restore our coastal blue carbon ecosystems. The term "blue carbon" refers to the climate sequestered and stored in coastal ecosystems such as mangroves, tidal marshes, and seagrasses. Blue carbon ecosystems act as long-term carbon sinks, are contained within clear national jurisdictions, and can be integrated into national greenhouse gas accounting. They also provide food and livelihoods while harboring incredible biodiversity, making their protection one of the most effective but most underutilized nature-based strategies to combat climate change. However, improper and inadequate management of coastal ecosystems has led to their dramatic decline. We have lost 50 percent of blue carbon ecosystems in the last 50 years, resulting in 450 million tons of CO_2 emissions annually.

However, aggressive conservation restoration efforts could result in climate mitigation benefits of 1.4 gigatons of CO_2 removals each year by 2050, roughly the annual emissions of all the cars in California, Texas, New York, and Louisiana combined.

Mr. GRAVES. Louisiana too?

Dr. HOWARD. Louisiana, too. No-regret strategy number 2: green-gray infrastructure. This is the fifth consecutive year in which there were ten or more weather and climate disaster events in the U.S. causing over $1 billion in damages. The need for coastal protection of both people and assets has never been higher. Green-gray infrastructure is a design philosophy that combines nature with the selective use of conventional engineering approaches to protect coastal communities and assets from climate change. By blending natural green conservation with built gray engineering techniques, communities can incorporate the benefits of both solutions in a more comprehensive, robust, and cost-effective way than implementing either solution alone.

No-regret strategy number 3: sustainable ocean use. Looking to the deep ocean, the U.S. has the largest economic exclusive zone in the world, with an ocean-dependent economy generating over $138 billion, mostly related to the fishing industry. Shifts in management of fisheries have the potential to ensure that that industry can adapt to climate change and produce an ocean that is more bountiful and profitable than it is today, thus securing a healthy source of protein in a world where climate change threatens food security.

Another way to safeguard against climate change is to protect at least 30 percent of the ocean by 2030. This 30-by-30 frame offers a target that would protect food supplies, bolster climate resilience, and provide safe spaces for marine life to rebound. Protecting 30 percent of the ocean and coast also offers an economic value estimated in the billions of dollars.

But what can be done? Conservation International wishes the committee to consider the following: the U.S. should expand and

accelerate conservation and restoration of blue carbon ecosystems for climate mitigation, as well as refine its use of coastal wetlands within the U.S. greenhouse gas inventory; we encourage U.S. decision-makers to include green-gray options in the coastal protection and budget plans; we recommend the committee promote effective fisheries and aquaculture management that provides adaptive capacity for communities in the industry and protects critical ocean biodiversity; and we recommend that the U.S. supports the creation and sustainable management of ocean conservation areas as a climate adaptation strategy, specifically related to aid going to large ocean states.

While much of the required emissions productions needed to keep us below 1.5 degrees Celsius temperature rise must come from decreasing use of fossil fuels, nature-based opportunities can also play a critical role in the transition to low-carbon future and a safe climate.

The earth, and specifically the ocean, can no longer be expected to take abuse and still provide for us in the same way. The planet, this pale blue dot, belongs to us and is ours to manage, and we can't retreat from that responsibility to manage it wisely.

Thank you for the opportunity to engage with this committee, and I applaud the committee's recognition of the ocean as a climate change solution.

[The statement of Dr. Howard follows:]

Testimony of Dr. Jennifer Howard
Director, Climate and Oceans, Conservation International

Before the U.S. House of Representatives Select Committee on the Climate Crisis
"Solving the Climate Crisis: Natural Solutions to Cutting Pollution and Building Climate Resilience"

October 22, 2019

OCTOBER 18, 2019.

Hon. KATHY CASTOR,
Chairman, Select Committee on the Climate Crisis,
House of Representatives, Washington, DC.

Hon. GARRET GRAVES,
Ranking Member, Select Committee on the Climate Crisis,
House of Representatives, Washington, DC.

Re: Select Committee on the Climate Crisis hearing on "Solving the Climate Crisis: Natural Solutions to Cutting Pollution and Building Resilience"

DEAR CHAIRMAN CASTOR AND RANKING MEMBER GRAVES: Thank you for the opportunity to provide input to the Committee's hearing: "Solving the Climate Crisis: Natural Solutions to Cutting Pollution and Building Resilience."

The ocean is the dominant feature of our plant, covering 70 percent of its surface and driving its climate and biosphere. It used to be assumed that the ocean was so large that climate change impacts on the ocean would be minimal but we now know this is not the case. The Intergovernmental Panel on Climate Change (IPCC) Ocean and Cryosphere report [1] describes these changes in no uncertain terms. Today's ocean is warmer, more stratified, and more acidic. Ocean heatwaves are killing our corals and rising sea surface temperatures are increasing storm severity resulting in the multitude of extreme weather events we have observed over recent years. As the ocean warms and ice melts, sea level is rising at an accelerating rate. How-

[1] IPCC, 2019: Summary for Policymakers. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate [H.-O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, M. Nicolai, A. Okem, J. Petzold, B. Rama, N. Weyer (eds.)].

ever, while much of the recent attention is focused on the problems that the ocean faces, the ocean is also a source of potential solutions and innovation.

The world needs to move rapidly and systematically to reduce emissions of greenhouse gases (GHGs) to the atmosphere if it is to avoid irreversible climate impacts.[2] [3] Greater efforts are essential to accelerate and scale decarbonization of the economy and pursue a pathway to net-zero emissions by the middle of the century. Following the findings of the IPCC Special Report on the implications of 1.5 °C warming above the preindustrial period, it is now abundantly clear that stronger action to mitigate GHG emissions is a global imperative that will require an inclusive approach across the whole of the global economy.

To date, much of the attention paid to nature based solutions to climate change has been directed to the role of terrestrial sources of emissions and sinks, such as the impact of tropical deforestation as a source of greenhouse gas emissions. However, oceans and coasts have recently taken center stage in the discussion of climate impacts and solutions; so much so that the upcoming global negotiations on climate action under the United Nations (COP25) to be held in Chile in December 2019 has been dubbed the "Blue COP". This is fitting, as ocean-based mitigation and adaptation options offer significant potential to contribute to global efforts to limit global warming as well as achieve the targets of the Paris Agreement and the Sustainable Development Goals.

The ocean is on the front lines of the battle against climate change. Not only has the ocean absorbed 93 percent of the heat trapped by rising anthropogenic carbon dioxide (CO_2), it also absorbs approximately 25 to 30 percent of anthropogenic CO_2 emissions that would otherwise remain in the atmosphere and increase global warming. Mangroves, salt marshes, and seagrass beds are highly productive vegetated coastal ecosystems and are hotspots for carbon storage, with soil carbon sequestration rates per hectare up to 10 times larger than those of terrestrial ecosystems.[4] When these ecosystems are degraded and converted, carbon in the vegetation and soils, which may have accumulated over hundreds or thousands of years, is oxidized and emitted back to the atmosphere in a matter of decades, leading to increased emissions. Thus, protection of these "Blue Carbon" ecosystems offers an efficient pathway to avoid CO_2 emissions, particularly for nations with large areas of coastal vegetation and high rates of loss. Similarly, utilizing these ocean related nature based solutions yields important co-benefits to local communities via other ecosystems services, such as providing habitat for commercially important fish species, food security, livelihoods, and reducing the impact of storms during extreme weather events as seen in hurricane Sandy where coastal wetlands prevented more than US$625 million in direct property damages by buffering coasts against its storm surge.[5]

Protection and restoration of ocean and coasts for climate mitigation and adaptation provides "no-regret" strategies, and thus Conservation International would recommend the Committee take into account the following four areas of ocean-based natural solutions to climate change in their formal recommendations. These key topics for oceans and coasts are Blue Carbon, Green-Gray Infrastructure, Sustainable Fisheries, and Large Scale Marine Protection.

BLUE CARBON FOR CLIMATE MITIGATION

Coastal blue carbon ecosystems—mangroves, tidal marshes, and seagrasses—are now an established key component of nature-based climate change mitigation strategies. Found at the interface between sea and land, these habitats sequester and

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[2] IPCC. 2014. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Edited by R.K. Pachauri and L.A. Meyer. Geneva: IPCC. www.ipcc.com.

[3] IPCC. 2018. Global Warming of 1.5 °C: An IPCC Special Report on the Impacts of Global Warming of 1.5 °C above Pre-Industrial Levels and Related Global GHG Emission Pathways, in the Context of Strengthening the Global Response to the Threat of Climate Change, edited by J. B. R. Matthews. Geneva: World Meteorological Organization.

[4] Mcleod, E., et al. 2011. "A Blueprint for Blue Carbon: Toward an Improved Understanding of the Role of Vegetated Coastal Habitats in Sequestering CO_2." Frontiers in Ecology and the Environment 9 (10): 552–60.

[5] Narayan, Siddharth, et al. "The value of coastal wetlands for flood damage reduction in the northeastern USA." *Scientific reports* 7.1 (2017): 9463.

store up to ten times more carbon, per unit area, than terrestrial forests.[6] [7] [8] There is growing awareness that the loss of coastal wetlands is contributing to global warming and that conservation and restoration of these wetlands may help to reduce or possibly reverse some of these impacts. In a global synthesis, it was estimated that converted and degraded coastal wetlands emit 450 million tons (Mt) of CO_2.[6] Such emissions are equivalent to 3 to 19% of those from deforestation globally and result in economic damages of USD $6 to 42 billion, annually. However, restoration of coastal ecosystems could result in potential climate mitigation benefits of 0.89 Gigatons (Gt) of CO_2 removals each year by 2030 and up to 1.38 Gt by 2050[9]—roughly the annual emissions of all the cars in California, Texas, New York and Louisiana combined.

Growing interest in coastal carbon sinks and sequestration—both in terms of scientific understanding and the climate change policy implications thereof—is driving rapid expansion of carbon dynamics research in coastal blue carbon ecosystems. In turn, this science has driven formal recognition of the importance of conservation and restoration of these ecosystems for climate change mitigation within international climate policy, finance and related management. Over the last seven years, Conservation International has been central to catalyzing this progress by facilitating and focusing research on priority policy-relevant topics and working to integrate that science into policy and management, leading to conservation, restoration and sustainable management of blue carbon ecosystems all over the world.

However, addressing the destruction of wetlands requires changing economic incentives that drive the destruction. Here, too, blue carbon can provide a solution. Governments should recognize the significant carbon impact from these ecosystems, and that protecting and effectively restoring wetlands is a key, but mostly forgotten, tool in the fight against climate change. Conservation International and our partners are building the conditions needed on the ground for large-scale application of blue carbon approaches—specifically the development of blue carbon credits that can be sold on the voluntary carbon market to provide start-up funding for conservation and restoration activities or that can be used to meet countries emissions targets. These sources of financing and associated policies represent a new avenue for protecting wetlands at a scale never achieved before. Blue carbon finance and policy aims to foster conditions where the full carbon value in these rich ecosystems, not just in the trees, but in the soil, is recognized and the financial remuneration available to conserve these areas is maximized.

In the U.S., federal agencies have established an interagency team to support blue carbon efforts. These include integrating blue carbon science and policy into the National Ocean Policy and activities to develop tools and methodologies for blue carbon management. The National Assessment of Ecosystem Carbon Sequestration and Greenhouse Gas Fluxes recognizes that national estimates of GHG fluxes are lacking and that filling this data gap is a priority. Whether to support national climate change goals, e.g. under a carbon finance framework, or to encourage less formal adoption of best practices, there is a need for refined quantification of GHG emissions and removals due to wetlands management at the national scale. Moreover, wetland climate change mitigation activities should be embedded within climate change adaptation strategies to avoid future negative outcomes related to coastal land-use planning.

GREEN-GRAY INFRASTRUCTURE AND COASTAL PROTECTION FOR CLIMATE ADAPTATION

Extreme weather events brought about by climate change are one of the most dangerous risks facing humanity.[10] Reducing this threat to vulnerable communities is a critical challenge of our time. These events have already caused devastating impacts on communities in many parts of the world, affecting people's lives and infrastructure in an unprecedented manner. In 2019 (as of October 8), there have been 10 weather and climate disaster events in the U.S., with financial damages exceeding $1 billion—for each event. Half of those were severe storm events, and two were

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[6] Pendleton, Linwood, et al. "Estimating global "blue carbon" emissions from conversion and degradation of vegetated coastal ecosystems." *PloS one* 7.9 (2012): e43542.

[7] Howard, Jennifer, et al. "Clarifying the role of coastal and marine systems in climate mitigation." *Frontiers in Ecology and the Environment* 15.1 (2017): 42–50.

[8] Simard, Marc, et al. "Mangrove canopy height globally related to precipitation, temperature and cyclone frequency." *Nature Geoscience* 12.1 (2019): 40.

[9] Hough-Guldberg, O., et al. 2019. "The Oceans as a Solution to Climate Change: Five Opportunities for Action." Report. Washington, DC: World Resources Institute. Available online at http://www.oceanpanel.org/climate.

[10] World Meteorological Organization (WMO) Statement on the State of the Global Climate in 2017, https://library.wmo.int/doc_num.php?explnum_id=4453.

tropical cyclone events. Overall, the extreme weather events this year resulted in the deaths of 39 people and had significant economic effects on the areas impacted. This year, 2019, is the fifth consecutive year (2015–2019) in which 10 or more billion-dollar weather and climate disaster events have impacted the U.S.[11]

Approximately $100 trillion of global infrastructure is estimated to be at risk due to inadequate insurance and risk management[12], while almost 1.9 million homes worth a combined $882 billion are at risk of being underwater due to sea level rise by 2100.[13] Across all future climate scenarios, no matter the degree of intervention, predicted impacts on coastal communities and assets are projected to be substantial and will cost up to 4% of annual world GDP by 2100.[14] That same modeling indicates that adaptation strategies can reduce these impacts by 2 to 3 orders of magnitude but will require an investment of USD $70 billion annually by 2100. *Green-gray infrastructure—a new approach to climate adaptation—provides cost effective approaches that can and should be a key adaptation solution for the U.S.*

Green-gray infrastructure combines the conservation and/or restoration of ecosystems with the selective use of conventional engineering approaches to provide people with solutions that deliver climate change resilience and adaptation benefits. Green-gray approaches draw upon the best of society's engineering achievements to innovate the next generation of climate resilient infrastructure. By blending "green" conservation with "gray" engineering techniques, communities can incorporate the benefits of both solutions while minimizing the limitations of using either green or gray infrastructure individually. For example, a combination of wetland restoration with limited geoengineering approaches, such as breakwaters, combines the wave attenuation and flood control value of wetlands with the benefits of engineered structures to stabilize the coastal zone and attenuate waves through beach accretion. The combined solution can be more comprehensive, robust and cost-effective than either solution alone. And these blended solutions can provide a host of multi-benefits:

- Habitat for fish and other aquatic species
- Employment opportunities for example, through enhanced fisheries
- Coastal protection to absorb and buffer wave energy and storm surge
- Carbon Capture, by conserving or restoring wetlands that capture and store five times more carbon than tropical rainforests, and
- Improving water quality by capturing, storing and filtering rainwater or stormwater.

These benefits are additional to the fact that green-gray infrastructure is often a highly cost effective alternative to traditional engineering only solutions, especially when considering the environmental and social co-benefits. For example, the installation of breakwaters that mimic the natural environment providing coastal marine habitat, increase sediment trapping to combat erosion and build up the beach, while at the same time reducing wave energy and protecting coastal communities and assets from storm surges.

For all these reasons, Conservation International has launched a green-gray infrastructure program to support communities around the world cope with the impacts of climate change, and we encourage U.S. decision makers to include green-gray options in their coastal protection and budget plans.

SUSTAINABLE FISHERIES FOR CLIMATE ADAPTATION

The ocean is the world's largest source of food. Seafood is the most traded food commodity globally and is the last global food commodity we hunt. Three billion people—three out of every seven on the planet—rely on seafood as a primary source

[11] https://www.ncdc.noaa.gov/billions/.

[12] Jupiter. (2018, February 12). Jupiter Launches Climate Data, Analytics and Technology Platform to Predict and Manage Weather and Climate Change Risks. Retrieved from https://www.globenewswire.com/newsrelease/2018/02/12/1339285/0/en/Jupiter-Launches-Climate-Data-Analytics-and-Technology-Platform-to-Predictand-Manage-Weather-and-Climate-Change-Risks.html.

[13] Zillow Research. (2017, June 2). Climate Change and Housing: Will a Rising Tide Sink All Homes? Retrieved from https://www.zillow.com/research/climate-change-underwater-homes-12890/.

[14] OECD (2019), *Responding to Rising Seas: OECD Country Approaches to Tackling Coastal Risks*, OECD Publishing, Paris https://doi.org/10.1787/9789264312487-en.

of animal protein.[15] Fisheries support the economies of developing countries worldwide, including over 260 million livelihoods.[16]

Half of the world's wild-caught fisheries are overexploited or depleted, due to overfishing, pollution, climate change and other threats.[17] Overfishing, increased illegal, unreported, and unregulated (IUU) fishing, and use of indiscriminate and damaging fishing gears have resulted in stock declines and collapses—impacting food security, livelihoods, and economies of coastal communities.

Aquaculture—fish farming—is one of the fastest growing food production sectors globally, accounting for half of the worldwide total seafood production. Intensive aquaculture has resulted in widespread degradation of coastal ecosystems from pollution, waste, and habitat destruction.[18] Sustainable aquaculture approaches with minimal or no net impact of coastal ecosystems are not widely used due to lack of capacity or economic incentives.

The problems of overfishing and unsustainable aquaculture are fueled by several factors. Demand for seafood is rising due to population growth, rising affluence, and globalization, and demand for fish as food for livestock and aquaculture operations is growing.[19] New technologies have multiplied harvesting capacity, and pollution and habitat degradation are reducing the productive capacity of fisheries ecosystems. These problems are magnified by ineffective policy and governance systems.

The benefits of investing in improved management of fisheries and aquaculture outweigh the costs on average 10:1, and effective conservation can produce positive outcomes for biodiversity and communities. One study concludes that under sustainable management, global fish production could increase by 14%, and economic profits can increase by 168%, reaching $74 billion a year.[20]

Dramatic changes to fishery management has the potential to adapt and compensate for the coming climate change impacts to produce a seafood future that is more bountiful and profitable than it is today—thus securing a healthy source of protein in a world where climate change threatens future food security. However, just because fishery management *can* improve, doesn't mean it *will*. Over the last two decades, CI has implemented successful initiatives to improve the environmental sustainability and social benefits of fisheries and aquaculture. We recommend the committee promote effective fisheries and aquaculture management which provide adaptive capacity for communities to successfully navigate the impacts of climate change.

LARGE SCALE MARINE PROTECTION FOR CLIMATE ADAPTATION

By reducing other threats to ocean ecosystems, such as destructive fishing, habitat loss, and pollution, Marine Protected Areas (MPAs) build ecological resilience and increase the ability of ecosystems, species, and communities dependent on the ocean for their livelihoods to adapt to climate change. When local communities and stakeholders are directly involved in the design, management, and benefit sharing, we see more successful outcomes. MPAs can also help build social resilience and adaptive capacity to climate change.

The IPCC Ocean and Cryosphere report[21] explicitly mentions the value of MPA's to increase societies' capacity to respond to climate change risks. To protect our ocean and ensure it can provide the resources we need for 7–11 billion people, we

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[15] Source: UNFAO 2014. Fish now accounts for almost 17% of the global population's intake of protein—in some coastal and island countries it can top 70%.

[16] Teh, L.C. and U. Sumaila. 2013. Contribution of marine fisheries to worldwide employment. Fish and Fisheries 14:77–88.

[17] UN FAO. 2014. The State of the World Fisheries and Aquaculture. [online] http://www.fao.org/3/a-i3720e/index.html.

[18] Hall, SJ., et al. 2011. Blue Frontiers: Managing the environmental costs of aquaculture. The WorldFish Center, Penang, Malaysia.; Troell, M., R. L. Naylor, M. Metian, M. Beveridge, P. H. Tyedmers, C. Folke, K. J. Arrow, S. Barrett, A.-S. Crépin, and P. R. Ehrlich. 2014. Does aquaculture add resilience to the global food system? Proceedings of the National Academy of Sciences 111:13257–13263.; Klinger, D., and R. L. Naylor. 2012. Searching for solutions in aquaculture: charting a sustainable course. Annual Review of Environment and Resources 37:247–276.

[19] Naylor, RL., et al. 2000. Effect of aquaculture on world fish supplies. Nature 405:1017–1024.

[20] CEA, editor. 2015. Ocean Prosperity Roadmap: Fisheries and Beyond. California Environmental Associates (CEA). [online] http://www.oceanprosperityroadmap.org/wp-content/uploads/2015/05/Synthesis-Report-6.14.15.pdf.

[21] IPCC, 2019: Summary for Policymakers. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate [H.-O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, M. Nicolai, A. Okem, J. Petzold, B. Rama, N. Weyer (eds.)].

must imagine and act at a scale larger than we ever have before. Effective place-based conservation and management safeguards biodiversity, replenishes fisheries, provides for the safety and security of people, and enables ecosystems to function as they should. A study conducted by Conservation International directly links marine managed areas with increased local incomes, food stability, and quality of life.[22] Areas with adequate capacity and funding are found to deliver almost three times the ecological benefits.[23] And a well-managed area reduces stress from unsustainable human activities, making the ocean system more resilient and better able to cope with climate impacts.[24] Because this approach works, the International Union for Conservation of Nature (IUCN) has called for 30 percent of the ocean to be placed in marine protected areas.[25]

Governments need to protect, conserve and sustainably manage vast stretches of ocean area, recognizing the tremendous benefits such actions yields both for nature and their citizenry who depend on the ocean culturally, socially and economically. Noting that there are many categories of MPA's from no-take zones to multiple use areas where protection and sustainable use are in balance. People—from local communities to heads of state—are now recognizing and prioritizing area-based strategies to protect and sustainably manage the ocean. However, the community of ocean conservation organizations and funders has not kept pace with this historic shift in attitudes toward and growing interest in protecting the ocean. A 2017 report commissioned by the Packard Foundation[26] found that only a small number of foundations give to placed-based ocean conservation, totaling $40 million annually. A significant increase in funding and support is needed to maintain momentum for ocean conservation globally.

Conservation International has prioritized catalyzing the creation and improvement of 18,000 km2 of ocean conservation areas and we recommend that the U.S. supports the creation and sustainable management of ocean conservation areas as a climate adaptation strategy, specifically aid going to large ocean states.

APPLICATIONS FOR POLICY

Each of these ocean-based natural solutions to climate mitigation and adaptation play a significant role in preserving wildlife, coastal communities and the sustainable marine based economies upon which they depend. Blue Carbon, Green-Gray Infrastructure, Sustainable Fisheries, and Marine Protected Areas can help us build resilience to the impacts of climate change that are being felt across our country and in every region on Earth.

There is a small, but important window of opportunity within which the emissions trajectory based on "Current Policy" can be directed towards a pathway that is consistent with limiting global temperature rise to the 1.5 °C and 2.0C goals determined through the Paris Agreement. While much of the required emission reductions must come from deep cuts within terrestrial-based activities, including decreasing the use of fossil fuel, ocean-based opportunities can also play a critical role in the transition to a low-carbon future and safer climate.

However, achieving the mitigation potential of ocean and coastal systems will not be possible without significant investment in research and development. It will also be necessary to provide strong incentives to align financial flows with the needs of the mitigation and adaptation opportunities available. Governments must send policy signals that these innovative, nature based solutions are a priority for combining climate adaptation and mitigation.

One of the first opportunities that governments will have to comprehensively integrate ocean-based mitigation options into national plans and strategies for climate change is the updating of national climate action plans in 2020. This is an extremely important moment, as emphasized by the IPCC (2018): the chances of "failing to reach 1.5 degrees Celsius [will be] significantly increased if near-term ambition is not strengthened beyond the level implied by current NDCs." Given the con-

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[22] Kaufman, Orbach. 2010. Marine Managed Area Science Project Synthesis: Report to the Gordon and Betty Moore Foundation. Conservation International.

[23] Gill et al. 2017. Capacity shortfalls hinder the performance of marine protected areas globally. Nature 543: 665–679.

[24] Roberts et al. 2017. Marine Reserves can mitigate and promote adaptation to climate change. National Academy of Sciences 114: 6167–6175.

[25] IUCN World Conservation Congress. 2016. Increasing marine protected area coverage for effective marine biodiversity conservation. WCC–2016–Res-053–EN.

[26] California Environmental Associates. 2017. Our Shared Seas: A 2017 Overview of Ocean Threats and Conservation Funding. Prepared with support of the David and Lucile Packard Foundation.

sequences of failing to limit global average temperature rise to 1.5C, or at least to "well below" 2.0C, it is of great importance that actions begin immediately.

Ultimately, the ocean, its coastal regions, and the economic activities they support should be a source of inspiration and hope in the fight against climate change. With the backdrop of a growing climate catastrophe, the timing of this Committee Hearing is critical, and there could not be a more compelling case for urgent action.

Thank you for your leadership in holding this important hearing. Conservation International values the role our natural environment plays in mitigating and adapting to the worst impacts of climate change. We look forward to working together to continue to develop policies that can help to accelerate action on climate change.

Sincerely,

JENNIFER HOWARD, PH.D.,
Director, Oceans and Climate Conservation International.

Ms. CASTOR. Thank you, Dr. Howard.

Now on to Andy Karsner. Welcome, Mr. Karsner. You are recognized for 5 minutes.

STATEMENT OF THE HON. ANDY KARSNER

Mr. KARSNER. Thank you. Chairwoman Castor, Ranking Member Graves, esteemed members of the committee, thank you for the invitation and the honor to testify before you today.

You have got a sample of why I am so proud to be associated with TNC and Conservation International, and Jen and her good work.

I want to thank the committee for the seriousness of purpose with which it is taking its task. Many people say that a committee without jurisdiction may not amount to serious consequence, but I have had the opportunity to get to know you both—and it was with such privilege, and it has come to my attention that this is one of the few oases in Congress where people can galvanize serious thought and coalesce into serious solutions. So there are great prospects for collaboration and where there isn't, there is an openness towards the virtuous competition of big ideas.

So I want to thank you both, because amongst the biggest ideas that this committee can prioritize in its recommendations going forward is how to use natural resource solutions and natural capital as a source of galvanizing a national consensus and bringing new value and prosperity to our communities.

As you have heard from the other witnesses, we are in an era where we can easily identify what the value of natural capital is and bring it to bear. They have told you what is available and to be accomplished. I would like to talk for a moment about how that can be done.

Before doing so, I would also like to compliment your staffs. I have had the chance to get to know, Ms. Cohen, Ms. Cassady, Mr. Hall, Mr. Banks, not just now in the context of this committee, but over their many years of service, including a dozen years ago when I myself was in public service, not just managing the Federal Applied Science Laboratories, International Labs, but also as a climate negotiator and principal architect of the Bali roadmap, the precursor to Paris.

At that time, it wasn't the most fun job description to be George W. Bush's representative abroad, entering the UNFCCC after a 10-year hiatus post Kyoto. But I would enter each meeting introducing myself as a child of the Apollo generation, and I would explain to

them that despite their own skepticisms, we Americans had a sensibility that there was no goal beyond our reach, that nothing was too distant, that all possibility existed in planetary solutions.

That is the type of optimism that we should have today, because we have more resources, more capacity, more innovation, and more possibility about addressing our climate conundrum, but we need to do it through the lens of climate math, and not merely entire debate on the validity of climate science.

Climate math means understanding and identifying what volume of emissions reductions is available, from what source, and at what price. And I urge the committee to move the discussion strategically in that direction on Capitol Hill, so that we can get with the spirit of this committee. We can proselytize that spirit and get into a competition of ideas about how to best achieve that climate math.

Unequivocally, the best way to do it is to have nature solve for nature. There is no greater source of emissions reduction available. There is no man-made technology that can exceed nature's capacity to absorb, to drain, to sequester, and to minimize carbon emissions.

And so the continuous dialogue about cutting of the spigot of emissions becomes less and less important going through time, relative to opening the drain and ensuring that we can return to a steady-state ecosystem by allowing nature to perform its own functions without degradation, and valuing those functions into our marketplace.

We have already launched a cascading series, a chain reaction of unintended consequences. And science and technology both would dictate that we have to have an equal and opposite reaction that is symmetrical if we are going to problem solve at the scale and the magnitude, and the timeframe of the problem that we are addressing.

I would like to believe that this can be done through natural capital resources which cumulatively can address up to 30 percent of greenhouse gas emissions. But it can only be done if it is brought into our market system and economy and valued appropriately.

For that, we must have price discovery of the true value of nature, of all the benefits that the other witnesses have described here today. We have to be able to identify, through information and analytics and insight, those indicators that will inform innovation for financial instruments, insurance instruments, commodity supply chains, and ensure that we can continue to grow and prosper even as we remediate and make our communities more resilient.

Madam Chair and Chairman Graves, thank you again for the opportunity to testify. I look forward to answering your questions, and I am truly grateful for the leadership you bring to this issue.

[The statement of Mr. Karsner follows:]

Testimony of The Honorable Andy Karsner
Executive Chairman, Elemental Labs

Before the U.S. House of Representatives Select Committee on the Climate Crisis
"Solving the Climate Crisis: Natural Solutions to Cutting Pollution and Building Climate Resilience"

October 22, 2019

Chair Castor, Ranking Member Graves, Distinguished Members of the Committee:

Thank you for the honor and the invitation to represent the innovation and conservation communities, which are increasingly convergent on our shared mission to enable community resilience, and to ensure the continuity of economic prosperity. It is increasingly clear that the essential pathway to these objectives involves understanding and applying the value of natural capital for the sustainable modernization of our market economy.

This year, we have been confronted with repeated reminders of the destructive violence and senseless damage climate change inflicts on our communities and ecosystems. These range from the raging wildfires in the Amazon and California to the intensified hurricanes relentlessly pounding our nation's southern and eastern coastal communities. Recurring heatwaves were the deadliest climate hazard from 2015–2019, affecting all continents and setting temperature records around the world. Even as Japan deploys resources and technology to fortify its physical resilience to natural disasters, many expressed in the wake of Typhoon Hagibis that the "best recovery strategy" is simply to persevere in the face of pain, suffering, and loss.[1] We are inching toward tipping points that threaten irreplaceable ecosystems such as tropical peatlands, mangroves, prairies, and seagrasses—all of which have a vital role in sequestering carbon and maintaining the Earth's delicate planetary equilibrium.

There is growing recognition that these human and ecosystem tolls will also likely induce a cascade of irreversible and poorly predicted economic consequences. The insurance industry and other stakeholders recognize that current flood risk assessment tools are too crude and outdated to accurately predict flood risk and assess the impact of mitigation investments, and that financial institutions and property owners have no accurate, standardized way to measure asset risk. This is also true of wildfires; Munich Re, the world's largest reinsurance firm, indicated that climate change was responsible for $24 billion in losses due to the 2018 California wildfires.[2] Last week, the CEO of already-bankrupt Pacific Gas & Electric (PG&E) warned of safety blackouts for another ten years to update equipment prone to sparking wildfires, which are becoming increasingly likely in California due to rising temperatures. All of this points to the urgent necessity to prepare and proactively transition our public policies and institutional management by thoughtful design.

A few days ago, the Federal Reserve Bank of San Francisco published a dire warning of the dangers climate change poses to America's businesses and communities, calling upon lenders and businesses to act swiftly. This is especially imperative since municipalities, counties, parishes, and local and state governments are unlikely to have the capacity or balance sheets to fully prepare through conventional mitigation and adaptation efforts. It is therefore urgent that this Committee prioritize recommendations for community resilience and maximize the value of local ecosystems in attenuating these known and rising risks to lives, property, safety, and security.

Economic effects have already been set in motion. These are not future, hypothetical risks to our collective prosperity. Rather, the market has already begun to take account of climate change, noting the insufficiency of policy guardrails, and has started discounting and devaluing real estate—our homes, schools, small businesses, factories, and infrastructure—accordingly. Properties which are likely to be underwater if sea levels rise by one foot now sell for approximately 15 percent less than comparable properties without this exposure to flood risk.[3] As this decline in prop-

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[1] The Independent, "'Everything is gone': Japan left reeling from worst storm in decades," October 19, 2019, https://www.independent.co.uk/news/world/asia/japan-typhoon-hagibis-storm-destruction-fukushima-a9163101.html.

[2] Neslen, Arthur. "Climate Change Could Make Insurance Too Expensive for Most People Report." *The Guardian,* 21 Mar. 2019.

[3] Asaf Bernstein, Matthew Gustafson, and Ryan Lewis, *Real Estate as a Tool for Adaptive Banking*, Community Development Innovation Review, Volume 14, Issue 1, 2019.

erty values sends signals to the rest of the financial system, banks may avoid lending to flood-prone areas in a practice called "bluelining", which will imperil the health and resilience of the often poor communities that are already vulnerable to these disasters. This is another form of regressive taxation imposed by neglect.

Credit rating agencies are deeply attuned as well. In 2017, Moody's warned that climate change would increasingly negatively affect the creditworthiness of U.S. state and local issuers, the cost of which flows through to American pocketbooks and livelihoods. Recently, both Moody's and S&P acquired significant stakes in leading providers of data, intelligence, and analysis on physical climate risk, indicating clearly that climate data and computational science will be key drivers in determining the cost of funds and credit for all of us.

Moreover, there are significant indicators that capital markets are both considering and executing dramatic shifts in how accounting is managed, information is exchanged, and disclosure is verified. The private sector is assessing contingent liabilities and incorporating unmitigated climate change risk into their reporting, planning, and strategic investing. Earlier this month, for example, eleven leading environmental and sustainable business organizations published an open letter in the New York Times urging corporate CEOs to increase their climate policy engagement. Over 160 companies overseeing $86 trillion in assets support the G20's Task Force for Climate Disclosures (TCFD), which has called for companies to disclose their exposure to climate risk. The Climate Action 100+ initiative includes 360 investors with over $34 trillion in assets under management, and aims to hold accountable the world's largest corporate emitters. Recently, 34 central banks—including the Bank of England and Banque de France—joined the Network for Greening the Financial System, which aims to ensure a smooth transition to a low-carbon economy. This network represents approximately half of global emissions and recommended that central banks act quickly to avoid a climate-driven abrupt collapse in asset prices.[4]

Various blueprints have been carefully laid out to map the path toward the net zero emissions future needed to avert the worst and least predictable climate impacts. Last year's IPCC Special Report on Global Warming of 1.5 °C concluded that to limit global warming to this level, global GHG emissions must decline by approximately 45 percent below 2010 levels by 2030. This would require rapid acceleration of solutions across sectors—energy, transport, buildings, and industry—with falling costs and rapid uptake of sustainable solutions.

Importantly, large-scale removal of atmospheric CO_2 will be absolutely necessary to avoid key tipping points and irreversible climate thresholds. Restoring degraded areas of land will likely be the only cost-effective way to remove atmospheric carbon at scale. Reforestation, biochar, and improved agricultural practices can prospectively store up to 9.1 billion tons of CO_2e annually, eventually storing 225 billion tons by the end of the century.[5]

Underpinning and cross-cutting these approaches is an exponential wave of American innovation and technologies that can far more effectively and sustainably strengthen our natural resilience, conservation strategies, and intelligent interaction with natural resources. We must modernize and design policies commensurate with the abundance of innovation that is revolutionizing our agriculture, food, forestry, aquaculture, and oceanic ecosystems, along with the global supply chains that connect them to the modern economy. This is the surest way to maintain American economic competitiveness, standards of living, and prospects for long-term prosperity as we adapt to new climate realities. With the right policy guidance, these technologies are poised to be game-changers for adaptive, agile, creative strategies to turn today's climate risks into problem-solving opportunities.

The fastest way to scale all of these changes is to address the core of the problem: the misalignment between markets and nature. Humanity's industrial-age relationship with nature is premised on the idea that natural resources are inexhaustible and can be consumed without limit. When embedded in markets, this assumption has led to the exponential scaling of behavior and outcomes that are detached from the true cost of irrationally depleting the asset value of healthy habitats. We are only beginning to understand with precision mispriced risk resulting from an inability to ascertain or quantify the gaps between asset prices and their underlying value. The net effect is mounting uncertainty, and the rising probability that the future does not resemble empirical models of the past. Financial regulators, banks, businesses, and to a lesser degree policymakers have begun sounding the alarm that

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[4] Exponential Roadmap 1.5: Scaling 36 Solutions to Halve Emissions by 2030, September 19, 2019.

[5] Exponential Roadmap 1.5: Scaling 36 Solutions to Halve Emissions by 2030, September 19, 2019.

a financial crisis of unknown proportions (exceeding the 2009 mortgage crisis) may be looming on the horizon.

It's worth remembering that virtually all of human civilization, including our moral beliefs and values, our social norms, and the democratic, free-market system that has produced unrivaled wealth and prosperity evolved in a relatively tranquil period on Earth, an interregnum between the end of the Paleolithic Ice Age, about 12 thousand years ago, and today. Our beliefs about the world, and our place within it, evolved in this nursery of stability and abundance, and it left its mark in our minds and in the systems we've built. The ideologies that won out in this period, rooted in the *conquest* of nature, in the possibility of limitless growth, and in our inherent separateness and superiority to other living things, require continued abundance and stability to underwrite and sustain them.

Today, the erroneous presumption, built upon prior generations' thinking, that the world provides unending resources is why we tend to measure and fully account for certain things (like the processed and manufactured goods we consume) and not others (the natural resources required to produce these material comforts). Yet this system will not survive unchallenged in an era of profound ecosystem volatility, disruption, and the loss of nature. Capitalism and our personal freedoms are cornerstones of modern society, but they are incomplete without a companion sensibility: the understanding that we are symbiotically enmeshed with the systems that make life possible, and that we must preserve them.

Without making these invisible relationships visible, the invisible hand of the market cannot work effectively. It will systematically discount those things that are vital and common, and advantage those things that are privately profitable but harmful to all. In other words, we are fortifying—with existing policy, or lack thereof, "tragedies of the commons" that undermine classic principles of free enterprise, such as personal responsibility and transparent accountability.

While Greta Thunberg has brought focus to a generation's attention and priorities, with moral clarity as to the present urgency, Congress and this Committee in particular have an enormous opportunity to galvanize all Americans to apply our nation's strengths to the magnitude of the challenge we collectively face. Principal amongst these is our unparalleled capacity to induce innovation and scale technological progress through market penetration at incredible speeds.

Rather than being burdened by guilt and despair, we can remain pragmatic and optimistic, realistic and resolute, to maximize Nature's capacity to act as our ally and innovate the tools and technologies that enable us to thrive in the rapid transition to a new era of deep decarbonization.

The inexorable and exponential evolution from an industrial and natural resource-intensive economy to a data information economy has afforded us an unprecedented opportunity to account with precision the true value of ecosystem services. It is possible now to integrate that value into the modern economy with price discovery and evolved accounting standards. We call this market-based methodology of unleashing the value of natural capital "Natural Currency". Natural capital is a well-known and respected tenet of conservation, and ensures that nature is inventoried and valued for its ecosystem services beyond its extractive value. Natural Currency goes one step further and seeks to enable efficient markets for price discovery and exchange of ecosystem services that align the interest of people with the health of their natural habitats. For example, the rate at which a southern pine forest in Florida absorbs carbon or a mangrove wetland in Louisiana or South Carolina buffers communities against sea level rise has an absolute and unequivocal economic value. It has previously been challenging to capture that value and integrate it into our markets and risk management decision-making, because of the lack of precision in measuring, managing, and monitoring the natural capital in such a way that it could be readily priced and monetized. These are two particularly powerful and intertwined levers: the creation of Natural Currency (i.e. integrating nature's true value into market-based solutions), and Nature's ability to increasingly provide and scale ecosystem services and nature-based solutions to climate change. To be absolutely clear, having had three decades of experience in energy technology research, development, commercialization, and financing, there is no pathway to successfully mitigate GHG emissions at the scale and within the timeframe needed, without designing systems to maximize the contribution of nature-based solutions.

THE NEED FOR NATURAL CURRENCY

A technological revolution is well under way in digitalization, robotics, synthetic biology, artificial intelligence, cloud computing, and the Internet of Things (IoT). These have been described as the biggest "wildcard" in navigating the economic transition ahead. The exponential growth of these technologies, if designed and de-

ployed efficiently, should spread across all sectors to maximize clean energy and material efficiency, support health and environmental restoration, facilitate the spread of creative disruption and proliferate the growth of new enterprise, and usher in an era of decentralized, democratized, localized infrastructure.

Specific applications might include the digitalization of the grid to enable its electrification and decentralization (including through new trading mechanisms such as blockchain); sharing models for energy usage in buildings; and improvements of delivery by optimizing shipments, routes, and traffic systems. Importantly, in the context of today's hearing, the same breakthrough tools and technologies available for our man-made logistics and trading systems are available for drawing upon our nature-based solutions, and can deliver such solutions to society and markets—often at lower prices with far more sustainable and effective outcomes.

We have the technologies to enable supply and demand prediction for food systems that track and trace what we eat and drink from farm or field to fork. We can track accurately and in real time the performance and prediction of not only deforestation, but also restoration and regeneration—with the precision of counting biomass tree by tree, and plant by plant. There are sensors and artificial intelligence that can locally ensure our oceans and waterways, including our largest source of seafood, aquaculture, remains healthy, cost-effective, free of toxins, and managed sustainably in concert with global climate challenges.

Such technologies can help make the invisible visible. For example, Planet, a global Earth observation organization based in San Francisco, has deployed the largest constellation of Earth-observing satellites in history. Together these satellites image the entire planet every day in high resolution—capturing every act of deforestation, every illegal fishing vessel, every crop growing in every field, everywhere, every day. In so doing, Planet's satellites—and other observation technologies—can help us "measure the treasure" of Earth's natural systems, in exquisite detail, in both time and space, and inform the kinds of "big indicators" that can inform our policies, our choices, our markets, and our social norms. Similarly, advances in optical and portable measurement tools, drones to detect and monitor leaks, and the Environmental Defense Fund's MethaneSAT program have made it possible to capture global, real-time data on methane leaks, which can be translated into actionable information for resource management via advances in machine learning. Better tools and better technologies for natural systems support both stronger ecosystems and stronger corporate balance sheets.

A critical role of policy will be to support and shape the digital revolution to align with the well-being of humanity and nature. This is not merely an imperative for sustainability and environmental health. Rather, this is an essential precursor for the United States to maintain technology leadership and accelerate its economic performance.

Perhaps most importantly, these technologies are enabling us to design, dynamically develop, implement, and account for credible, verifiable natural capital metrics. Through these metrics, it is possible to establish a globally recognized set of reliable criteria to support environmental sustainability, social responsibility, and stronger communities that thrive with greater economic opportunity.

Tying verification and measurement to objective, quantifiable, real-time monitoring will unlock possibilities for value creation and accountability enforcement across all industries and sectors. We now have the ability to harvest data from countless sources, embedded on land and in the air, in the ocean, from satellites, sensors, and citizen scientist networks, to create complete, real-time visibility of land and oceans. What we need first are indicators that tell us about the health and welfare of the essential and fragile systems on which life depends. Today, we don't have a "NASDAQ for Nature" or a "Dow Jones for Deforestation"—but in the future, we must. I urge the Committee to seriously account for America's present technological leadership and the overwhelming abundance of innovation that is bursting from our country's entrepreneurs and laboratories, that can be applied with immediacy and impact, enabling our economy to prosper through unprecedented problem-solving at scale.

Innovation abounds in financing instruments that catalyze capital toward climate resilience. This is largely due to the recognition by the financial sector and business at large that climate change risks are real, and strategies incorporating financial opportunities that identify and monetize the value of ecosystem services may be economically advantageous. This value has previously been difficult to capture with any precision, let alone monetize. Historically, market design either discounted or disallowed any quantified value for natural capital beyond its physical extraction and consumption, instead relegating a science-based approximation to the domain of non-market actors such as governments, academics, and nonprofits.

New financing mechanisms are being driven by the recognition that we have access to measurement and evaluation tools to correct our markets. Technologies that meaningfully measure the progress of ecosystem performance are critical enablers of contractual and business model innovation. The data needed to underpin these decisions is often already available and being collected, but has been insufficiently indexed and categorized according to common frameworks to be of maximum value to investors and other stakeholders. This *information* must be sifted and processed to illuminate the underlying *insights*, and make them organized, scalable, maintainable, and easily accessed through open APIs. This would underpin leading *indicators* that can predict financial and economic climate-related outcomes, developed with the scientific community. Such verifiable, objective, third-party indicators would reverse the longstanding assumption that the market clearing price of natural capital is zero, and set the stage for an era of natural monetization, and perpetual innovation and evolution of financial *instruments* to redirect capital and redistribute risks.

These standardized, verified metrics enable more concrete and meaningful environmental and social governance (ESG) reporting. Embedding climate risk into asset prices also drives large-scale mainstream investors toward decisions beyond traditional "impact" investing, also unlocking significant arbitrage opportunities for those who effectively integrate climate risk. Alongside their recognition of the threat posed by climate change and mispriced assets, the investment community has begun to recognize the opportunities for those who access the right information and analytics to equip more accurate price discovery. For example, Blackrock, one of the largest holders of U.S. securities, released a report this year drawing on granular climate modeling and big data techniques to show variation in physical climate risk by region. Although slower-moving changes such as sea level rise may seem distant and difficult to model, their granular assessment of local climate risks shed light on implications for the U.S. municipal bond market, real estate, and the vulnerabilities of the U.S. electricity sector due to aging and vulnerable infrastructure.

The scale of the climate change challenge we are seeking to address is asymmetrical to the solutions, whether man-made or natural, we have thus far deployed. There is no possibility whatsoever that this country, or any country, can tithe or tax its way to a solution in the relevant timeframe. It is essential that we address market imperfections and harness market forces to enable the scaled benefits of nature-based solutions. No other source of deep decarbonization is more readily available, nor more measurably attainable, than the power of nature itself. Therefore I encourage the Committee, in its final report, to prioritize and recommend on a bipartisan basis, that the value of natural conservation, assessed and delivered through technological innovation, be paramount.

ECOLOGICAL PROSPERITY IS ECONOMIC PROSPERITY

The power of Natural Currency to unlock opportunities for economic growth and new abundance should not be underestimated, and would address the single greatest cause of misalignment between markets and nature. Once natural capital and ecosystem services are properly valued and market priced, the flow of capital to realign markets and nature will inevitably be reflected in market-based, cost-benefit decisions by municipalities, engineers, architects, building materials manufacturers, investors, insurers, consumers, and others across the economy.

For example, the innovations in spatial assessment and measuring capabilities described above can help identify degrees of ecosystem degradation, anticipated trends in biodiversity and other climate patterns, and the ecosystem services that restoration techniques could re-introduce to these landscapes. These advances in predictive power lessen the need for risk management and reduce investment risk from the public and private sectors. They enable greater inclusion of private sector participants, especially including small businesses and everyday citizens, in investment opportunities designed to capture the value of nature-based benefits while strengthening our local communities' resilience and adaptation.

Abundant application of innovation to accelerate nature-based solutions already exist. In one example, intelligent risk management services focus on quantification and valuation of blue carbon (as discussed by my expert colleague from Conservation International) in coastal and marine systems. The carbon mitigation benefits of mangroves are immense; they store up to ten times the carbon of terrestrial forests on a per area basis, while protecting more than ten million people globally from flooding, and reducing flood damage to coastal assets by more than $82 billion each year. The market is already producing a new wave of entrepreneurs to create revenue streams for mangrove conservation and restoration by incorporating their risk

reduction value into insurance products, and monetizing the climate mitigation value of mangroves through "blue carbon credits".

By managing sites where mangroves provide verifiably high flood reduction benefits, linking these to site-specific calculation of flood risk benefits, and securing annual payment from insurance companies for continued, verified mangrove conservation and restoration, new jobs are created, new enterprise thrives, and communities are protected with greater resilience and the benefits of their stocks of natural capital. This assessment and monetization of coastal asset risk reduction value, and the natural benefits of mangroves, is enabled by unprecedented technological advances for precision quantification and calculation methodologies that support credible, verifiable third-party standards for voluntary carbon markets. As infrastructure turnover accelerates toward more sustainable assets, there will also be opportunities for project developers to support green infrastructure and access the value created by nature-based solutions.

CONCLUSION: DESIGN A JUST TRANSITION THAT ACCELERATES INNOVATION, "MEASURES THE TREASURE", VALUES AND PRICES NATURE-BASED SOLUTIONS, AND STRENGTHENS COMMUNITY RESILIENCE, ADAPTATION, AND PROSPECTS FOR PROSPERITY

To support economic development and community adaptation and resilience in the face of inexorable climate change, it is essential for policy design to integrate the intrinsic benefits of American innovation, which is advancing technological solutions that interface with natural systems as never before. As has been the case throughout our history, America's investment in creating a technology push through research and development has been facilitated by "demand pull" in the marketplace, shaped by policy priorities for the public good. This is as true for the revolution in renewable energy as it has been for GPS, the Internet, and many other innovations that have emerged from effective policy and governance. This is particularly true in developing standards of measurement and management (such as those at NIST), especially in the early stages of a technology's emergence in the marketplace. Examples might include:

—A "Natural Capital Innovation Prize" investing in the most effective means for American citizens (and/or institutions, such as small businesses, secondary schools, universities, and civic organizations) to directly participate, protect, and restore carbon-rich natural ecosystems at home and abroad, with higher funding to scale winning solutions.

—Ensuring that insurance commissioners have no impediment to innovation in regulation that allows products to integrate climate risk reduction and mitigation measures, including nature-based solutions. Additionally, aligning market-based incentives with preventative preparation and resilient adaptation to respond to the evolving frequency and severity of catastrophic weather events.

—Policies to encourage true cost accounting, informed by transparency and disclosure, with precision measures and metrics where governmental institutions take account for the power of tools and technologies to deliver the next generation of accounting performance

—Natural capital "opportunity zones" corresponding to measurable, vital ecosystems

These examples illustrate the range of ways in which policymakers can create demand for, and directly benefit from the measurement and management of natural capital, and subsequent market realignment. Such measures can create the regulatory environment needed to guide the application of these exponential technologies to their highest value.

While there are many bold and often controversial ideas for costing up carbon, there are too few policy proposals circulating that directly incentivize decarbonization. Last year, Congress passed into law a provision known as 45Q, that provided tax credits for man-made forms of carbon sequestration, discriminating and discounting conservation and ecosystem services with superior scalability, volumetric availability, immediacy, and permanency. In other words, the most effective, efficient, sustainable, and immediately available solution for decarbonization was disincentivized relative to more speculative future technological bets. While I am a strong supporter of funding multiple innovation pathways for rapid and deep decarbonization, the highest priority legislative fix to unleash natural capital innovation would simply be to allow such solutions to access the 45Q sequestration tax credits—or, alternatively, to design a tax credit for that purpose.

Despite the daunting nature of the climate crisis, as with any risk, there is also veiled opportunity—for human ingenuity, for optimism, and for entrepreneurial solutions to achieve what may be possible. Climate risk represents inordinate scale—in fact, planetary scale. And yet this grand challenge we face together, across na-

tions and our common humanity, compels us to unleash American innovation in technologies, policies, and market design. In doing so, we heighten the probability that we will successfully address this mounting challenge, with a resilient strategy to adapt and thrive in concert with the natural systems that sustain us. These systems will continue to give life to our communities and posterity, defining our collective legacy at this pivotal inflection point in the history of our nation and our global commons.

Ms. CASTOR. Well, thanks to all the witnesses for your compelling testimony. I recognize myself for 5 minutes for questions.

Okay. So to give Americans and the world the best chance of avoiding the worst consequences of the climate crisis, the Intergovernmental Panel on Climate Change found that global greenhouse gas emissions will need to drop by 45 percent by the year 2030 and reach net zero by the year 2050.

Research shows that natural climate solutions can provide one-third—I think, Mr. Karsner, you just referenced that—can provide one-third of the emission reductions needed to meet these targets.

So to all of the witnesses—I will go down the row here—I would like you to prioritize what nature-based solutions you would highlight to us as we develop a National Climate Action Plan, national climate policy to achieve net zero emissions.

Dr. FARGIONE. Thank you. Well, there are several. So, for example, reforestation is one of the largest opportunities. Planting trees has a very clear, consistent carbon benefit and a lot of co-benefits. Also, avoiding forest loss and grassland loss and land use through land use planning, and reducing urban sprawl is important.

And there are many opportunities in our agricultural sector that often are overlooked. So building soil health and improving nutrient efficiency which has strong co-benefits for water quality.

Wildfire risk reduction is something that has strong co-benefits, that as we are dealing with forest fire on suppressed lands, and improve forest management through creating opportunities for private, forest land owners to tap into the carbon markets, and improve their forest management. All great opportunities that should be prioritized and included in a Climate Action Plan.

Ms. CASTOR. Okay. Vice Chairman Myers?

Mr. MYERS. Supporting forest sequestration, carbon sequestration, expanding the carbon program to include federal lands, and looking at including cultural, traditional, and prescribed burning on a landscape level to help protect our forests from catastrophic wildfire, while also renewing the growth of carbon through the current trees that we have in the ground.

Making sure that we fund those programs adequately, and have a honest discussion as a nation, about how cultural burning and traditional burning are viewed as a whole, and move away from catastrophic fires that we have seen to devastate our forests.

Ms. CASTOR. Dr. Howard, you had a long list for us. Which ones would you highlight to us, that would be the most impactful?

Dr. HOWARD. Can I share with Andy still?

Thank you. So I think in terms of climate mitigation, I think one of the big strategies that not only the U.S. but the world needs to be considering is putting blue carbon ecosystems, their conservation and restoration, into their climate NDCs under the Paris Agreement.

Many countries have already included these ecosystems, but the ambition can always be increased, including here in the U.S. And many countries including increasing that ambition can simply be including that ecosystem where it hasn't been before. Because they are so carbon-rich, that can really improve their ambition just by simply including that one additional system in their land-use sector.

And then for adaptation, I would strongly recommend that we invest a lot more in this green-gray infrastructure design, because in that sense, you are also utilizing all the co-benefits of a natural ecosystem related to the fishing industry, food security, cultural practices, but then also increasing the flood plain, and doing that first, and then building gray infrastructure on top of that to cover just what is needed, versus the reverse, which is building gray infrastructure first and then the green comes in second, and usually that doesn't work as well.

Ms. CASTOR. Mr. Karsner.

Mr. KARSNER. Thank you. So I will have just a little bit of a different twist because I can't possibly compete with the expertise of identifying each economic—each ecological benefit.

I am as or more concerned with how to access those ecological benefits as to how to identify them. I don't think there is any shortage of solutions, whether it is blue carbon, whether it is coral reef abating storm surge, or mangroves sequestration, or forestry. We have no shortage of available solutions.

We have a dearth of our capacity to access those solutions because presently we value nature in the wrong way. When we value a tree as wood, or wood only, or even in a virtuous way as forestry stewardship certified wood, we fail to value it for how it is respiring and sequestering carbon or true cost account for it.

So what I am proposing is greater transparency and disclosure in the way accounting is done for nature, so that more dollars flow in a more symmetrical way to natural capital solutions.

My colleagues have identified what those solutions are. We can't possibly mine all those solutions in our lifetime, but we can spur the capital formation to direct ourselves in a symmetrical way to solutions in the way that we have created problems.

And so I am hopeful that the committee will take up and recommend that these natural capitalist solutions are eligible for sequestration credits under 45Q in the same way that a man-made sequestration research and development project is. If we have solutions available for wind and sun, to offer tax credits, certainly we should for land and soil and storm abatement and things that protect our coastlines.

Ms. CASTOR. Thank you very much. Mr. Graves, you are recognized for 5 minutes.

Mr. GRAVES. Thank you, Madam Chair. Madam Chair, years ago we worked with Nature Conservancy to help identify some of the priority areas in South Louisiana where we had coastal forests, cypress and tupelo and other species, that played important natural-buffer roles for our sustainability.

We were able to pioneer efforts to engineer oyster reefs in our coastal communities where we could design them in geometric for-

mations where you could channel the wave energy up instead of into communities.

The oyster reefs would create cleaner water; it would sequester carbon in the shells; it created habitat for many other species; of course, the biomass from the oyster reefs themselves were beneficial.

Win, win, win, win, win. You had storm-surge benefits. You had cleaner water benefits. You had the biomass and ecological productivity benefits. I mean just, again, win, win, win. And we would design those in strategic areas of our coast where we needed that type of performance. It worked really well.

I think that here, as you have heard from our witnesses, we have another—or other opportunities, plural, to build upon those types of successes. And as mentioned, I think bringing in our farmers, an extraordinary untapped resource in terms of natural resources management, that can come into the fold and work with us to complement some of our efforts here.

And I think also as mentioned, some of our federal resources, in terms of our national parks and wildlife refuges, and BLM land and forest and other assets.

Mr. KARSNER—Karsner, excuse me—you have probably more expertise than just about anyone in the States in terms of using capital formation and incentives to sort of complement or maximize the benefits of our natural system. In response to the chair's question, you talked a little bit about tweaking incentives, but as you know, the United States spends an extraordinary amount of money today in research and development, basic energy, as well as clean energy technologies.

You are king for the day, what do you do? How do you tweak those incentives to help to maximize our natural systems and the potential benefit there or how the natural systems can complement some of our efforts to help to sequester and reduce greenhouse gas emissions?

Mr. KARSNER. Thank you, sir. It will hurt some of my colleagues' feelings being that I am a former wind developer and have invested in solar and electric cars, and I am still as enthusiastic in green technology as anybody you could possibly meet. But having managed that portfolio for the federal government, I saw the lines cross, and they are not going to reverse.

The federal government is lagging and not leading in terms of the research that it is investing in energy technologies for the most part. That is not to say it doesn't have a vital and crucial role that shouldn't be fortified, but it needs to move on and move at the pace that the evolution of innovation is taking place in the markets.

The real revolution that is happening that can most affect this domain and particularly things like farmers and soil and the ecosystems we talk about, are not the things that are coming—or leading in our national labs.

They are data science, information technology sensors, artificial intelligence, machine learning, robotics, the internet of things. That whole network, that whole capacity to make what has previously been invisible and unquantifiable become visible and quantifiable, and migrate into our risk management decisionmaking, migrate

into our investment calculus, migrate into the way we think of the world around us, is a game-changing revolution.

There is an example where we have robotics that can serve farmers right now that are picking berries in the fields of some of America's largest berry-pickers. They are also taking soil carbon and moisture-content samplings. They are gathering such an extreme amount of data that can be monetized to understand how sequestration works.

I use that in a minute example because I know from your experience and the one you just characterized, we have known these things for years. We just haven't brought valuation to them.

And we cannot tithe our way charitably, nor tax our way through government, to the amount of money that is necessary to invest in natural capital and nature solutions. We have got to tweak policy and incentives to shift that capital into that problem space.

Mr. GRAVES. Thank you. And, Madam Chair, let the record reflect the witness said he wants to give trees iPhones. No.

Thank you very much. I think you made an excellent point in that we have so much data out there, but we are not properly quantifying it or evaluating it and comparing it to other expenditures and uses to determine how do you maximize the taxpayer funds that we have.

I think it is an excellent point, and I think that it is largely an untapped resource. I see—before you—let me take this away for a minute. So—no, very quickly, I am going to pretend like we are very close instead of butchering your last name.

Dr. Joe, could you quickly talk about the Lower Mississippi River afforestation project that you all are working on and how that plays into this?

Dr. FARGIONE. Sure. We identified the Lower Mississippi Valley as a great place for a reforestation project. The trees grow quickly, the land is relatively cheap, and there is ability to tap into carbon markets.

And so those kind of targeted restoration efforts that also have co-benefits in terms of wildlife and improving water quality are the kind of thing that would be unlocked if there was additional incentive to invest in natural climate solutions.

Ms. CASTOR. Thank you very much. Ms. Bonamici, you are recognized for 5 minutes.

Ms. BONAMICI. Thank you very much, Madam Chair, and thank you to our witnesses for your testimony, for bringing your expertise.

I want to start by following up on Dr. Howard's testimony. We know that every person on the planet benefits from a healthy ocean. It supplies oxygen that we breathe and regulates our climate; it is linked to the water we drink; it is home to a significant amount of life on the planet; it drives our economy; it feeds, employs, and transports us, and today our ocean is threatened more than ever.

Last month—you mentioned this, Dr. Howard—the United Nations Intergovernmental Panel on Climate Change released a "Special Report on the Ocean and Cryosphere in a Changing Climate." The findings are dire. The ocean is becoming more acidic. It is warming. It is losing oxygen as a direct result of human-caused

emissions. So I am glad we are discussing today the opportunity for the ocean to be part of the climate solution.

I co-chair the House Oceans Caucus and the Congressional Estuary Caucus, and I am working on legislation to strengthen, restore, and protect our wetlands, to store blue carbon.

My bill will create a national level mapping of blue carbon ecosystems and their sequestration potential, study the effects of climate change and other environmental stressors on the rates of carbon capture and storage, improve protections for existing blue carbon ecosystems, and restore and expand degraded wetlands.

So Dr. Howard, in your testimony, you discuss how blue carbon ecosystems have—and I will quote—soil carbon sequestration rates per hectare of up to ten times larger than those of terrestrial ecosystems.

So can you talk about what the scientific research gaps may be in our current understanding of blue carbon and its sequestration potential, and also discuss the role of wetlands as a climate adaptation tool for coastal communities?

Dr. HOWARD. Thank you very much, Chairwoman, for that question. So in relation to how do you use blue carbon ecosystems to increase our coastal climate mitigation strategy, especially regarding restoration, I think one of the things that we really try to highlight in the research that we do and the research gaps that remain is that these coastal ecosystems, just as you said, they store ten times more carbon in the soil than terrestrial systems per area. And that is largely because of the salt water that is washing over them twice a day with the tide.

That salt water inhibits microbial action, therefore, you don't have degradation. And so when we are talking about research gaps, I think one of the big ones is that when you go to develop that area, and let's say you are draining it for agriculture or for hotel development or coastal development—when you start to develop that area and you drain that system, all of that microbial action kicks back in and you get all the degradation, and then you get all of the emissions.

However, how long that takes, how much of that soil is actually susceptible to that turning from a carbon sink into a carbon source, still needs to be a little bit better defined. Right now, under the IPCC, we assume that the top meter of soil is actually at risk of all that carbon being released, and that is easily about a hundred to a thousand years of carbon accumulation that can be released within a decade.

But we think that it is incredibly conservative, and probably, most likely, much deeper soils as far down to three, four meters could actually be at risk, depending on which actual conversion has happened. Was it agriculture, was it development, was it draining for something else——

Ms. BONAMICI. And I don't want to cut you off, but I really wanted to get another question in.

Dr. HOWARD. Sure.

Ms. BONAMICI. So I really look forward to following up with you and working on this issue. But I have limited time.

And I wanted to ask Vice Chairman Myers, I am from Oregon, your neighbor to the North. In your testimony, you mentioned that

to avoid disruptions and threats to your survival, natural resources were managed comprehensively for ecosystem-wide health, and you said that harvesting and gathering of resources were closely managed and in rhythm with natural cycles.

So how does the Yurok Tribe define sustainable forest management, and in addition to prescribed burns, what other practices do you use to restore forests to their natural healthy state? Can they be replicated or incentivized at the federal level?

Mr. MYERS. Absolutely. Thank you for the question. I think one of the obstacles that we face are jurisdictional issues. Managing a land on a holistic level, you have to see the landscape without jurisdictions, and without the permit issues that we have seen.

The tool that we have found to be seen to be most effective to protect the forest is the use of cultural burning, but also making sure that we use proper logging techniques, to create uneven aged stands of forest that go back to more of a traditional forest landscape.

And so I think much of what we discuss is not to preclude timber harvesting, but to use it as a management tool, along with our traditional methods for land management which include traditional fire at a landscape level.

And I think that is what is important. Up to this point, fire on the landscape has been used for pilot projects, but I think expanding that has to be done on a landscape level.

In California and Oregon, catastrophic wildfires are the fear that we live with on a daily basis. And the destruction to our families and our homes and our communities is second only to the fear of destroying our entire landscape as a whole.

Ms. BONAMICI. Thank you. I see my time is expired. I yield back. Thank you.

Ms. CASTOR. Mr. Carter, you are recognized for 5 minutes.

Mr. CARTER. Thank you, Madam Chair, and thank all of you for being here. This is certainly an important subject, and we appreciate you lending your expertise to it.

Ladies and gentlemen, I have the honor and privilege of representing the entire coast of Georgia, over a hundred miles of pristine coastline, and I am very proud of it. It is my home, it is where I have lived all my life and intend to live the rest of my life. And it is right at the tip of the sphere, if you will, on what has been happening with climate change.

In fact, we have had three hurricanes in the last 3 years and barely dodged one this year with Hurricane Dorian. And as a result of that, we have taken on a number of projects in trying to make our communities more resilient because we feel like resiliency is extremely important. And I want to tell you very quickly about a couple of those.

First of all, the University of Georgia, along with the Army Corps of Engineers and some private sector companies and nonprofits have taken on an initiative called "Engineering With Nature," where we use natural sediment in a way that makes beaches and wetlands and communities more resilient, and that is very important.

And also in Jekyll Island, in Jekyll Island in Glynn County, the Army Corps of engineers is working on a project that rearranges plough mud in the intercoastal waterways to protect the marshes.

And Tybee Island, which is one of our barrier islands in Chatham County on the coast, they have done a number of different initiatives. In fact, they are the first community in the state that has come up with a community-wide sea-level plan, and also, they are very involved in projects dealing with sand dunes, and that is certainly with dune restoration. I had the opportunity to visit and see some of this with them, and this is extremely important.

I want to ask you, Dr. Fargione—is that fair enough? Okay. These projects have been associated with federal funds, and I just wanted to ask you, how important is it to make sure that we at the Federal Government prioritize these projects and make sure that we are getting them done in a quick manner, in a way that we can make sure that these projects are done as soon as possible?

Dr. FARGIONE. Certainly there is a need for increased investment in those coastal ecosystems' protection and restoration. And they have this dual benefit, as you say of storm-surge protection and flood-risk reduction.

One of the other benefits they have is through storing carbon, and even further, some of our salt marshes, when they are disconnected from the ocean, they become freshened and they begin to emit methane, which is a potent greenhouse gas.

And so simply reconnecting those salt water marshes and making them salty again can reduce methane emissions and have a significant climate mitigation benefit. And that also restores their ecological function as an estuary by reconnecting them with the ocean. So that can be as simple as widening culverts and putting in——

Mr. CARTER. Right.

Dr. FARGIONE [continuing]. Tide gates.

Mr. CARTER. Well, let me ask you this. You are familiar with the discussion about climate change and the conversation. Do you think we are concentrating enough on resiliency, or do you think that we need to look more at how we can make our communities more resilient?

Dr. FARGIONE. I think there is a great opportunity to increase the resilience of our communities, and it is this mix of gray and green infrastructure, if you will. But we have underinvested in that green infrastructure, and preventing development of places that are at risk, and maintaining that natural habitat as a buffer for storm surge is a great way to do that.

Mr. CARTER. And you would agree that we have got to have a buy-in by the private sector, that they have got to be part of this, and in order to have that buy-in by the private sector and to have their participation in this, we need a strong economy. So you would agree that a strong economy is important to this as well?

Dr. FARGIONE. Certainly one of the potential sources for investment in natural climate solutions and protection is through voluntary carbon offsetting, and that is something that we are already seeing, that in these—some industries like the airlines, where it is very hard to use anything other—to replace the jet fuel with renewables, they are planning to offset those emissions and having that go to things that also increase resiliency is a win-win.

Mr. CARTER. Good. I don't mean to be redundant, but I am constantly reminding my colleagues up here on the dais that Georgia is the number one forestry state in the nation and that it is extremely important that timber, of course, it helps us in removing carbon and how important that is.

And just wanted to make sure that I get that plug in again, that the number one forestry state in the nation is doing our part in trying to remove carbon from the atmosphere.

And with that, I will yield back.

Mr. GRAVES. Madam Chair, I want to remind you from our last hearing that after the gentleman from Georgia left, we were able to track that data, and it was based on the number of trees per person with a funny accent in the United States.

Ms. CASTOR. Any rebuttal? No. No, okay.

Mr. CARTER. It is not deserving.

Ms. CASTOR. Ms. Brownley, you are recognized for 5 minutes.

Ms. BROWNLEY. Thank you, Madam Chair. Mr. Karsner, I wanted to ask you a question. I was very interested in your testimony about natural capital, and you talked about the valuation of natural capital. Where does the carbon tax fit into all of that, or does it?

Mr. KARSNER. Separate issue. It fits in at a macroeconomic scale of saying, how do you create value for something? So taxation, of course, is the government's blunt-force instrument to tip the scales and create value. When I think of natural capital, it is not a government-driven thing. It is a science-driven thing that says, what is the intrinsic valuation of the southern pine forests in Georgia which breathes, or respires, at a different rate than redwoods in California.

And that respiration should be valued for its carbon sequestration asset value, and somebody should pay for that service. It is an ecological service.

So they are not at all mutually exclusive in the sense that both of them shift the way that we value and bring on the value of nature.

But one, I think, is a top-down jurisdictional instrument, the taxation. The other is a bottom-up assessment of the true asset value of something we should be accounting for in the profit and loss of every decision that we make.

Ms. BROWNLEY. Thank you. I wanted to ask each and every one of you with just a yes or no answer, in order to get to the goal of a net zero emissions by 2050, do you think a carbon tax is an important component piece to getting there? Just I will start with you and go down the line.

Mr. KARSNER. Yes.

Dr. HOWARD. Yes.

Mr. MYERS. [Speaking native language.]

Dr. FARGIONE. We support a price on carbon, whether that is a tax or cap and trade, but yes.

Ms. BROWNLEY. Okay. Tax, fee, cap and trade, putting them all in the same category, roughly. So, Dr. Faragano—Fargione? Dr. Joe.

So I wanted to talk a little bit about urban forestation. So I noticed in your priorities, you didn't mention that at all. You talked

about forest management. And so in terms of planting trees in our urban areas, is that a significant—is there a significance there in terms of moving the needle with regard to carbon emissions?

Dr. FARGIONE. Yeah. There is a surprising amount of opportunity. We estimate there is up to 8 million acres in our cities around the country that could have—of more tree cover that we could have.

And it has surprising benefits. So even today, the existing tree cover, it helps prevent about 1,300 deaths in heat waves. Largely from people that don't have access to air conditioning.

Ms. BROWNLEY. Sure. In my district, the City of Oxnard has got a grant from the State of California to plant a lot of fruit trees in an area that really in parts of the city of Oxnard is disproportionately affected by pollution.

And so it is certainly a carbon emissions reduction tool, but also sort of a climate justice tool, all built into one. Are there other programs that California is doing to incentivize better forest management, urban forestation, that the Federal Government could be looking at?

Dr. FARGIONE. I am not familiar with California programs, but I can follow up with you on it.

But certainly there is an opportunity to do more because when it comes to urban forest, it is not just about planting new trees. It is about protecting the trees we have, because those urban trees are at risk of disease, and so keeping those trees——

Ms. BROWNLEY. And one last question. So in my district, I represent the county, Ventura County in California, and we have had two of California's historically largest forest fires have taken place in my district over the last 16 months.

So when we talk about better forest management and reforestation and the balance, if you will, of resiliency and wildfire management, you know, help me, how do we balance those things through policy efforts?

Dr. FARGIONE. Yeah. I think we have the capacity to reforest in places that need it, and also to do wildfire risk reduction treatments in places that need it. They both require investment.

Ms. BROWNLEY. Thank you. I yield back.

Ms. CASTOR. Mr. Palmer, you are recognized for 5 minutes.

Mr. PALMER. Thank you, Madam Chairman. Dr. Fargione? Is that close? I mean——

Ms. CASTOR. Will you just say it once for all of us?

Dr. FARGIONE. Yeah. Dr. Fargione.

Ms. CASTOR. Fargione?

Mr. PALMER. Fargione. I will just call you Joe.

Dr. FARGIONE. That works, too.

Mr. PALMER. All right. In your testimony you highlighted a variety of ways that forests can be used to positively impact the climate, but could you discuss in more detail the negative impacts of wildfires on the climate?

Dr. FARGIONE. Sure. So when forests burn, that emits carbon, and so it is somewhat counterintuitive that one of the things that we recommend is cultural burning, which emits some carbon, but over the long term, what we are doing is restoring the balance.

Places that have had fire suppression, they have lots of small-diameter trees that serve as kindling, and so then when it does burn, it becomes very difficult to control and you see some of the catastrophic wildfires that make the news.

Mr. PALMER. But isn't it also true that one of the reasons that the fires burn so hot is that we failed to manage the forests properly and there is enormous amounts of fuel on the forest floor?

Dr. FARGIONE. Yes.

Mr. PALMER. The other issue is that there are certain types of forest that fire is absolutely critical for continued growth. And the redwoods, long lake pine in the southern states, require management by fire.

The other thing is, it was stated, I think there is this assumption that it is the old-growth forests that do the most for carbon sequestration, and that there is no place, in certain cases for clear-cutting.

And the fact of the matter is, there is a new study out of the University of Birmingham—Birmingham, England. I am from Birmingham, Alabama. I want to make sure everybody knows that. It is Birmingham, England—that the younger forests sequester more carbon, I think it is like 25 percent more.

And I am a forest owner, and I understand that you need to have forest at different stages of growth. So there is a place for forest management that includes clear-cutting certain cases, definitely thinning to prevent catastrophic wildfires, but it also increases the habitat for wildlife.

And I see Mr. Myers, Vice Chairman Myers nodding, you understand this. I just want you to comment on that, because I think that needs to be part of our efforts to mitigate climate change.

And the interesting thing about this study is that we typically think of the main body as a forest for carbon sequestration being the rainforests, the tropics, but it is really the more temperate areas, the eastern United States, parts of Canada and Russia, the Boreal Forest in Canada. You want to comment on that?

Dr. FARGIONE. Sure. So there is a couple things in there. One is, you know, forest products are a renewable resource and so that is great where we can support those industries.

So products like cross-laminated timber, or other forest products that are coming on the market that be can used in buildings, can displace some other really carbon-intensive products. So we think that, you know, responsible, well managed forests are something we need more of, and it is a renewable resource.

In terms of the age of the tree, if you think about how fast the forest grows is one thing, but what we are talking about in terms of fighting climate change is taking more carbon out of the atmosphere and having it on the landscape, and that means having more older trees.

So one of the things that actually, yes, having that younger tree growing fast, but also having longer rotations. If you go from having a 20-year rotation, the average age is 10 years, and you have got, you know, a certain amount of carbon. But if you have a 40-year rotation, the average age is 20 years. You have doubled the amount of carbon on the landscape.

So, yes, manage forests, yes, renewable resources, but also thinking about extending those rotation ages can help store more carbon in the landscape.

Mr. PALMER. When you are talking about a younger forest, you are typically talking, though, about under a hundred years, a forest that is not a hundred years old. And when you are talking about forest products, even with pine, for, like, you mentioned laminated wood products, you are talking 20, 25 years before that forest would be harvested. For hardwoods it is much longer.

I do think that this should be a part of our discussion about mitigation for climate change, and part of our strategy should include planting more forest and having this scaleable plan for reforestation and younger and older forests.

With that, Madam Chairman, I yield back.

Ms. CASTOR. Thank you. Mr. Huffman, you are recognized for 5 minutes.

Mr. HUFFMAN. Thank you, Madam Chair. Dr. Fargione, I was going to just say your name to show that we could do it.

But my first question is actually for Vice Chairman Myers. I appreciated your testimony, Mr. Vice Chairman, about some of the tools that the Yurok Tribe is using to restore forest land and manage it for the values that you mention, including carbon sequestration.

But one of the things you also mentioned was collaboration. And, of course, in northern California, we have a patchwork of land ownership and land uses. A lot of your good work has happened in areas where ownership is a mix of the U.S. Forest Service, the National Park Service, private land owners that are your neighbors, and, of course, tribal land that belongs to you.

Can you talk about how improved collaboration could help us scale up our carbon sequestration efforts when it comes to forest management?

Mr. MYERS. Absolutely. The success the Yurok has seen and others around us has solely been through the partnerships that we have with the other agencies within our ancestral territories and our watershed. That is absolutely what drives it.

Around the turn of the century, we have seen a breakup of our landscapes throughout the nation, moving to smaller parcels, both private and federal and state ownership. That makes land management extremely difficult to—navigate, and the only way through that—no pun intended—thick forest is to use partnerships and to have people working together, especially at the state and the federal level, with private industry and tribal organizations.

I think through private foundations we have been able to help fill the holes in the State and Federal programs, and allowing there to be a nexus between all of those is really the path forward across the board.

Mr. HUFFMAN. All right. Thank you.

Dr. Fargione, I really do have a question for you. The last line of questioning was about reforestation. And I wanted to ask you to speak to, what is the current rate of reforestation that you see, and how much more would we need to ramp that up to really put a dent in this problem?

Dr. FARGIONE. Sure. There are, you know—there is large reforestation potential, you know, over a hundred million acres that could be reforested. Right now, the amount of reforestation, I don't have those numbers at my fingertips, but it is a drop in the bucket from what it could be.

So—and that is on both—there is opportunities on private lands and also on some federal lands in places where many places that—where there was fire or pests or drought that killed trees, and maybe some of those will come back naturally and some of them won't, and could be opportunities for——

Mr. HUFFMAN. But it is not happening.

Dr. FARGIONE. It is not.

Mr. HUFFMAN. We have got a lot of untapped potential here, and we are not addressing it.

Over to Ms. Howard—Dr. Howard, if we wanted to go really big on coastal wetland restoration and blue carbon, what would a program like that look like, kind of similar to this challenge of we know reforestation would be good for us for our climate goals, but we are just not making it happen. What do we need to do?

Do we need a no-net-loss policy? Do we need some hard targets to achieve? Do we need to set up mitigation banks? What are some of the things you would like to—if we put you in charge of this and we wanted to go big?

Dr. HOWARD. Yes to everything that you just said. Thank you for answering my question for me. But in all seriousness, I think one thing, you know, one thing to remember, too, is that mangroves, which are primarily found in Florida but all over the world, and provide a large mitigation service, are forests.

So thinking about how do you include mangrove forests into all of the other forest regulation that we provide. But then I think it really gets down to this—where I would go big—is really integrating blue carbon ecosystems and green-gray infrastructure. Those two things are complementary. They go together and can be done simultaneously. And it is going to be probably the best chance that we have to protect against climate change along our coasts where most of the global population will be living within the next 50 years or so.

So expanding coastal conservation and restoration, and combining that gray-built infrastructure which we traditionally do, but really expanding the green because that is going to also have the climate mitigation benefit and the carbon mitigation benefit as well.

Mr. HUFFMAN. I am going to try to sneak one more question in to Mr. Karsner if I can.

You described the importance of better accounting for the carbon sequestration benefits of some of these natural systems. I can appreciate that, but at the same time, you seem to suggest that a carbon tax or carbon pricing wasn't necessary.

How does capital move into these natural systems if you don't have some kind of a forcing mechanism like a carbon pricing system that forces offsets and investments in those things?

Mr. KARSNER. Sorry, sir, I may not have made myself clear. I certainly did not intend to give the impression that I did not think a carbon price was a beneficial thing.

My point was that they are not mutually exclusive. They are separate and distinct and that we are in an era of such tremendous change that we can't afford not to hedge. One pathway is dependent on a government action; the other pathway is dependent on market redesign. If I had my preference, I would execute on both pathways.

Mr. HUFFMAN. Okay.

Mr. KARSNER. So the idea of transparency and disclosure for precision and price discovery, so that the benefits of blue carbon or sequestered—sequestration in mangroves being brought to a valuation is the surest way to move private capital. That does not alleviate the government of its responsibilities to appropriately price a negative attribute.

Mr. HUFFMAN. Appreciate that clarification. Thanks.

Ms. CASTOR. Mrs. Miller, you are recognized for 5 minutes.

Mrs. MILLER. Thank you, Chair Castor and Ranking Member Graves, who just left. Last week this committee held a fascinating hearing on how we can better construct our buildings and infrastructure to be more resilient in the face of extreme weather events.

During that hearing, I discussed how my home state of West Virginia suffered a major flood in 2016, which devastated many communities. Many of the solutions we have discussed in this committee, like carbon capture, building resiliency, and natural solutions, are all pieces of the same puzzle that fit together in the broader picture of caring for our environment and addressing climate change.

To further build upon our discussion last week, West Virginia produces some of the best hardwoods in the world. In fact, we are number two in the country in hardwoods, but my friend left, so I can't rub that in. A big part of the economy in the state is focused on the hardwoods industry. Good forest management not only leads to a healthy ecosystem, but also to a healthy economy.

Dr. Fargione, can you discuss how natural climate solutions can help build resilience for extreme weather events such as floods?

Dr. FARGIONE. Certainly. So if you think about our natural landscapes, when they are healthy, they act as a sponge. So when heavy rains come, they are able to absorb that, and that is, you know, obviously true in wetlands, and protecting and restoring those has a strong benefit there. It is under-appreciated in agriculture lands, how building soil health increases the amount of the ability of the soil to hold water, which can have a flood reduction benefit.

So those are all ways in which we, you know, the landscape can help store floodwaters.

Dr. HOWARD. Would it be possible to add to that quickly?

Mrs. MILLER. Yes, yes.

Dr. HOWARD. So when looking at coastal ecosystems, what happens upstream and up rivers is also incredibly important. So as you maintain the forest and reforest along river banks, you are preventing some of the downstream impacts along the coast. So protecting forests upstream can also increase coastal protection along the coast.

Mrs. MILLER. I am glad you brought that up, because particularly with our geography in West Virginia and going down to the Ohio River, and the New River—that is where we go.

Many of the practices you identified are targeted toward working lands such as farms, forests, and ranches. If land owners decide to implement these practices, can they expect any benefits beyond reducing carbon emissions?

Dr. FARGIONE. Certainly. So there is benefits in forests and crop land and range land on all of those. So in crop land, building soil health and improved nutrient management. Building soil health increases the fertility and, as I mentioned, the water-holding capacity of the soil, which is beneficial for yields and also, in particular, in drought years. Because that, acting as a sponge, it holds more water, making it more resilient during a drought.

In range land, this is an area that requires more scientific research to demonstrate—more consistently achieve these benefits, but there is some evidence that practices like rotational grazing can help increase the productivity and store more carbon in grazing lands. And in forests, there are practices like removing competing vegetation that actually help the forests grow faster, which is storing more carbon and making it more productive as timber land.

Mrs. MILLER. Thank you.

Mr. KARSNER. Representative Miller, may I comment on that?

Mrs. MILLER. Sure.

Mr. KARSNER. There are many ways, as we just described, that one could characterize as a quality of benefit. I want to be perfectly clear about what is possible with natural capital. If you can quantify it, if you can measure it, then you can monetize it. Those farmers should be paid—paid—cash for soil sequestration of the carbon.

We should be creating prosperity and incentives that align with the societal objective that we seek. We can do that, but it is going to take breaking the tyranny of accounting where we value nature at zero.

And to actually assess the benefit beyond organic, low-till farming, et cetera, and to actually say, we should be paying for what we want to occur, we are going to need natural capital accounting standards.

Mrs. MILLER. I was going to ask you to talk more about how we, as policymakers, can help encourage innovation in the natural solutions space. So I think you just answered my question before I asked it. So thank you very much. I yield back.

Ms. CASTOR. Mr. Neguse, you are recognized for 5 minutes.

Mr. NEGUSE. Thank you, Madam Chair. Natural solutions are an important piece of solving the climate crisis, and certainly that has been adduced through both the testimony from the witnesses today as well as the comments of my colleagues.

And while I am sure we will explore agriculture in more depth in the future, I wanted to highlight the importance of considering agriculture partners when we are discussing climate solutions.

In July, earlier this year, I introduced two bipartisan bills, the study on improving lands, or SOIL Act, and the Sustainable Agriculture Research Act, and the goal of these bills is to support the efforts in carbon sequestration on agriculture on federal lands. And I would be remiss if I didn't thank my colleague who is not here

today, unfortunately, but Representative Armstrong who joined me in Colorado recently on a tour of Boulder County.

And some of the—to visit with some of the farmers and farming communities in my district that are doing some pretty incredible regenerative agriculture practices, and to your point, sir, with respect to the exchanges previously, are engaged fully with the local jurisdictions.

So the city and the county officials, in a pretty robust program that essentially incentivizes farmers in our community to adopt some of these practices and to essentially take advantage of rotational practices in terms of helping grazing to sort of recover some of the soil in lands that have been depleted.

So a number of really incredible synergies that are happening, I think across the country, certainly including in my home state, in Colorado, and in my community. And I am glad that we have the opportunity to talk about some of those today.

I wanted to focus in on—and I apologize if this has already come up, I suspect it came up during your testimony, Dr. Fargione. I think that is right. Okay, so—right? I will check with——

Mr. HUFFMAN. Yeah. Nice work.

Mr. NEGUSE [continuing]. Check with Representative Huffman before I—but that is the LWCF, and since it was enacted over a half a century ago, the Land and Water Conservation Fund has helped conserve and safeguard thousands of acres of natural areas across the United States, including nearly 200 projects in Colorado's Second District alone that, as I mentioned, I have the honor of representing.

The funding really is critical for protecting national parks, areas around rivers and lakes, national forests, national wildlife refuges from development, as well as providing grants to—excuse me—to protect working forests and wildlife habitat, increase the use of easements, and fund state and local park and recreation projects.

As I know you are, no doubt, aware, earlier this year the Congress permanently reauthorized the LWCF but failed to provide permanent funding for the program. There are a number of us who, you know, have been advocating to the appropriators obviously in the House but also our colleagues in the upper chamber, to ensure that any omnibus funding bill that is—compromise that is reached includes funding for the LWCF. And so I am wondering if you could just describe the ways in which that funding can be an important tool to address the climate crisis, both with respect to mitigation and to resilience.

Dr. FARGIONE. Yeah. Thank you for that question, and for your support of the appropriations for LWCF. As you have noted, it is the primary federal program for preserving lands and waters and has protected countless forests, parks, wetlands, and other public lands, and—that sequester millions of tons of carbon.

So maybe just one example. In the San Bernardino National Forest in Riverside, in San Bernardino County, that sequesters about ten million metric tons of carbon a year in its forests, and over 36 million metric tons of CO_2. And that has received over $22 million in LWCF investments since it started in growing that.

So these lands that are being protected by LWCF are a really crucial part of natural climate solution, and I hope we can get it permanently funded.

Mr. NEGUSE. Well, thank you, and we are certainly going to keep working towards that end.

And with that, I would just say again thank you to Madam Chair for hosting this important hearing. I am very appreciative. I think that the focus on natural solutions, this is one of those areas in which there is a real potential for bipartisan solutions to emerge and I think looking at this holistically and engaging stakeholders from across the spectrum. So I am grateful for the Chairwoman's leadership.

And with that, I would yield back the balance of my time.

Ms. CASTOR. Mr. Casten, you are recognized for 5 minutes.

Mr. CASTEN. Thank you, Madam Chair. Thank you so much to all our witnesses.

Mr. Karsner, I really, really appreciated your testimony. I think we tend to talk too often about government solutions, which are important—and I agree with you, it is critical—but our climate crisis is, in the first instance, a market failure. You only have to look at how many countries use so much less energy per dollar of GDP than we do to recognize that opportunity.

And, you know, as I point out to my colleagues all the time, we are already making some progress towards fixing that, in spite of our regulations, not because of them. Because at the end of the day businesses like to make money, and if you have a zero marginal cost source of energy, it is kind of a money-making machine.

It also happens to lower carbon, if you do that right. But I think we would all agree that a lot more can be done, and as you—I liked your phrase in that you said we need to make the invisible relationships visible. And I want to hone in on one aspect of this, which is the disclosure that companies make as investors try to evaluate what they do.

I guess the first question is just if you would agree that while there certainly are plenty of good actors in the space, would you agree that corporations and financial institutions in the United States and arguably globally, are not yet doing enough to disclose the risks posed to their investors by the pending climate crisis.

Mr. KARSNER. Thank you, sir. I wouldn't agree with that as a uniform statement. I certainly think that is true and would apply to some, but I mean, I can think of outstanding leaders like Walmart, Google, Dow Chemical. There are many that are——

Mr. CASTEN. Sure.

Mr. KARSNER [continuing]. Using international, voluntary performance standards that are world class, but there is not a compliance standard that ensures that uniformly we are doing it. So one could say we are lagging in general, but I wouldn't say universally that is true across the board.

Mr. CASTEN. Yeah, no, and thank you for the clarification. Because that is why I said at the start there, good actors—I sometimes think that Walmart's commitment to buy a hundred percent clean energy would be something that we should follow since I think Walmart's the number 2 electricity consumer in the country, and the Department of Defense is number 1.

Maybe we could find some things we could copy there from the private sector. But let me just pick up on what you said, because this sort of universality of disclosures, would you agree at least that the current range of disclosure protocols is inconsistent and, therefore, how public corporations disclose the risk has a pretty wide error band around it?

Mr. KARSNER. Absolutely true, and I think that the amount of undisclosed risk is sufficiently opaque, that Congress should be significantly alarmed about how mispriced risk is affecting things in the marketplace today.

Absent any policy guardrails, the market is moving on, it is discounting real estate prices, it is making insurance unaffordable for homeowners along the coast, in the Carolinas, in Florida. It is even making insurance inaccessible in some places.

So the delta of mispriced risk that is occurring in the marketplace, versus the government's assessment or compliance standards for it, is a significant gap, and I would find it to be a worrisome gap.

Mr. CASTEN. Do you think there is a role for us to at least standardize the way in which those risks are disclosed?

Mr. KARSNER. Yeah, I personally think it is fundamental to the functioning of a marketplace to have transparency and disclosure, accountability, and responsibility of all the actors, whether they are individuals, homeowners, small businesses, or corporations. That is what makes a market function well, with societal guardrails, to an outcome that our representatives would prescribe.

Right now, I think we are neglecting that objective, and I think Congress has an opportunity to say, this is the accountability we would want. What we are looking at is a classic economic tragedy of the commons. This is all ball. And the question is, what will the remedy of the commons be?

And the remedy will be accountability through transparency and reporting that has people making risk management and investment decisions based on accounting for the value of nature.

Mr. CASTEN. Well, first off, when we are done here, I may hire you for my comms director. And don't get me wrong, my comms director is awesome. You can apply for the job. Put it that way, it is going to be contentious.

But this is precisely why I introduced H.R. 3623 with Representative Cartwright. Senator Warren is leading the Senate version of this. And, you know, coming from the private sector, I am not aware that you can choose, as a corporation, any flavor you want of how to disclose your liabilities.

Gap says what the liabilities are. And while ESG reporting is terrific, there is a wild disparity in how companies report the liability that their investors face on climate change.

And what the Climate Risk Disclosure Act would do—it passed out of Financial Services earlier this month by the way—would prior public corporations to disclose information relating to their financial and business risks associated with climate change and would require them to do that in a standard way.

And, you know, as I sit here and look at how investors make decisions, investors balance risk and return. But if the risk isn't dis-

closed in a consistent way, it is very hard to expect consistent returns.

So thank you, and I encourage all of my colleagues to follow the good guidance of our excellent witness. I yield back.

Mr. HUFFMAN. And support your bill.

Mr. CASTEN. And support my bill, yes.

Ms. CASTOR. Terrific. Well, I want to thank the witnesses and all of the Members for engaging today on these important natural solutions.

As we have heard, nature offers us so many solutions to the climate crisis, and I think we have identified common ground—pun intended—for our March committee recommendations. I want to remind everyone that we have a request for detailed policy proposals on our website, House.climatecrisis.gov. The deadline for those recommendations for the committee is November 22nd.

But I also wanted to highlight a report that came out yesterday that Chairman Paul Tonko hosted the scientist over in the Rayburn. They were from Woods Hole Research Center, and their just-released study said that the Arctic now in winter is releasing carbon dioxide, making it a source of carbon, rather than a sink that we had all hoped would be maintained.

But the earth is warming, the Arctic carbon deep freeze is breaking, and that is one of the reasons that we have all got to work together to follow the science and develop bipartisan climate solutions to tackle the climate crisis. So thank you all for being here.

I want to ask unanimous consent to include in the record the summary for decision-makers of the report, The Ocean As a Solution to Climate Change.

Dr. Jennifer Howard is one of the authors of this important report, and it was this high-level panel for sustainable ocean economy is a unique initiative of 14 serving heads of government, including Australia, Canada, Chile, and other countries.

So without objection, this is entered into the record.

[The information follows:]

Submission for the Record
Representative Kathy Castor
Select Committee on the Climate Crisis
October 22, 2019

ATTACHMENT: Hoegh-Guldberg, Caldeira, Chopin, Gaines, Haugan, Hemer, Howard, et al. *The Ocean as a Solution for Climate Change: Five Opportunities for Action*. World Resources Institute, 2019.

The report is retained in the committee files and available at: http://live-oceanpanel.pantheonsite.io/sites/default/files/2019-10/19_PAGER_HLP_web.pdf.

Ms. CASTOR. Thank you all for being here today. The committee's adjourned.

[Whereupon, at 3:35 p.m., the committee was adjourned.]

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